Approved Course Pattern and Syllabi w.e.f. 2010-2011 academic year
Credit System in M.Sc. (Meteorology)

I-Year First Semester

Course No.	Title of the Paper	Periods per week L	P	T	Internal assessment marks	Semester end examination marks	Total Marks	Credits
Theory:								
M–101	Physical and Dynamical Climatology√	4+1*	-	4+1*	15	85	100	4
M–102	Physical Oceanography√	4+1*	-	4+1*	15	85	100	4
M–103	Physical Meteorology√	4+1*	-	4+1*	15	85	100	4
M–104	Dynamical Meteorology√	4+1*	-	4+1*	15	85	100	4
Practicals:								
M–105	Meteorology and Oceanography√ Computations√	-	6	6	15	85	100	4
M–106	Observational Techniques√	-	6	6	15	85	100	4
M–107	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	90	560	650	26

I-Year Second Semester

Theory:								
M–201	Synoptic Meteorology √	4+1*	-	4+1*	15	85	100	4
M–202	Cloud Physics and Radar Meteorology	4+1*	-	4+1*	15	85	100	4
M–203	Dynamical Oceanography√	4+1*	-	4+1*	15	85	100	4
M–204	Advanced Dynamical Meteorology√	4+1*	-	4+1*	15	85	100	4
M-205	Elements of General Meteorology (OD)	4	-	4	15	85	100	4
Practicals:								
M–206	Synoptic Analysis√	-	6	6	15	85	100	4
M–207	Statistical and Numerical Methods using Fortran Programming √	-	6	6	15	85	100	4
M–208	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	105	645	750	30

II-Year Third Semester

Theory:								
M–301	Monsoon Dynamics	4+1*	-	4+1*	15	85	100	4
M–302	Air Pollution Meteorology	4+1*	-	4+1*	15	85	100	4
M–303	Numerical Weather Prediction	4+1*	-	4+1*	15	85	100	4
M–304	Air-Sea Interaction√	4+1*	-	4+1*	15	85	100	4
M-305	Global Warming and Climate Change (OD)	4	-	4	15	85	100	4
Practicals:								
M–306	Numerical Weather Prediction	-	6	6	15	85	100	4
M–307	Air Pollution	-	6	6	15	85	100	4
M–308	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	105	645	750	30

II-Year Fourth Semester

Theory:								
M–401	Satellite Meteorology	4+1*	-	4+1*	15	85	100	4
M–402	Dynamics of Climate Change	4+1*	-	4+1*	15	85	100	4
M–403	Climate Modelling	4+1*	-	4+1*	15	85	100	4
M–404	Agricultural Meteorology	4+1*	-	4+1*	15	85	100	4
Practicals:								
M–405	Applied Meteorology	-	6	6	15	85	100	4
M–406	Dissertation	-	6	6	15	85	100	4
M–407	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	90	560	650	26
	Grand Total (1+2+3+4 semesters)	64+16*	48	112+16*	390	2410	2800	112

* Tutorial √ Common Subjects for M.Sc (Physical Oceanography) OD – Other Department

M.Sc. Meteorology

Syllabi for I year – First Semester
M-101/PO-101: Physical and Dynamical Climatology

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. Jet streams. 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:

Fundamentals of Climate change - local and planetary evidences - carbon dating - theories of climate changes; Paleoclimate - Climate change and variations in Earth's orbit; Climate trends - ENSO - teleconnections of the world climate system - Ozone hole; Nuclear winter ; Global warming -Consequences of global warming; Volcanic eruptions and aerosols; Impact of climate change on weather and climate; Climate change and agriculture

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

M-102/PO-102: Physical Oceanography

Unit-I:

Physical properties of seawater: Temperature, Salinity and Conductivity, Density, Sound in the sea, Light in the sea, Colour of seawater. Temperature, Salinity and density distributions. Transparency of seawater.
Heat budget of the oceans: Heat budget terms, Short and Long wave radiation, Evaporation, Heat conduction.

Unit-II:

Oceanographic Instruments: Temperature measurements; Protected and unprotected reversing thermometers, MBT, XBT, XCTD, ARGOS, Drifters, Sea Gliders, CTD. Current measurements: Lagrangian and Eulerian methods with examples, Aandhera current meter, ADCP, Position fixing at sea, GPS. Wave and Tide measurements.

Unit-III:

Marine Geology: Continental shelf; Slope, Shelf sediments, mineral resources of the world ocean, submarine topography, mid oceanic ridge system. Manganese and other deposits and the factors control their distribution. Beach material, Shape and size. Beach terminology.

Marine chemistry: Composition of seawater, constancy of composition, dissolved gases, oxygen in the ocean, transfer of particle-aerosols, plankton and climate, bio-geo chemical cycles, marine environment and their characteristics, Marine Eco - system, Rocky shore, Sandy shore, Mangroves and Seaweed

Text books:

1. Descriptive physical oceanography by G.L. Pickard and W.J. Emery
2. Oceans by Sverdrup and Johnson and Flemming
3. Descriptive physical oceanography by M.P.M. Reddy
4. Introduction to Physical Oceanography by Bob Stewart, Texas A&M University (http://oceanworld.tamu.edu/resources.../contents.html)
5. Regional Oceanography by Tomczak, Matthias & J Stuart Godfrey (http://www.es.flinders.edu.au/~mattom/index2.html)
6. Physical Oceanography. Douglas R. MacAyeal (http://geosci.uchicago.edu/~drm7/res...eanography.pdf)

M-103/PO-103: Physical Meteorology

Unit-I:

State of the atmosphere : Main constituents of dry air, carbon dioxide, ozone, ozone depletion, water vapour and aerosols; Vertical thermal structure of the atmosphere : Troposphere, stratosphere, mesosphere, thermosphere and exosphere; Environmental lapse rate; Standard atmosphere; Hydrostatic equilibrium; Hydrostatic equation; Geopotential; Equipotential surfaces.

Measurement of temperature: Response times of Thermometers, Liquid in glass Thermometers, and Electrical Resistance Thermometers. Semiconductor Thermometers, Bimetallic Thermometers, Thermocouples.

Measurement Atmospheric Pressure:
Mercury barometers-Fortin and Kew, Corrections of Barometer reading to standard conditions. Aneroid Barometers, Piezo – resistive Barometers.

Unit-II:

Thermodynamics of dry air : Equation of state, Expansion of gas under constant pressure; Law of conservation of energy; specific heats of a gas; First law of thermodynamics; Adiabatic process in the atmosphere; Potential temperature; Equation state of dry air; Poisson's equation for dry air; Alternative forms of the energy equation; Entropy; Enthalpy.

Thermodynamics of moist air: The three states of water substances; The Classius and Clapeyron equation; Equation of state for water vapour; Moisture variables (Absolute humidity, specific humidity, relative humidity, mixing ratio); Relationship between R_m and R_d; Virtual temperature.

Isobaric processes for moist air: Dew point temperature; Wet bulb temperature; Equivalent temperature; Adiabatic expansion of unsaturated air; Adiabatic expansion of saturated air.

Vertical stability of the atmosphere: Dry adiabatic lapse rate; Standard adiabatic lapse rate; Equilibrium states; The parcel method; Application of the parcel method; Latent instability; The slice method; Relation between potential and latent instability; Stability of layers. Cloud Classification, Condensation nuclei; Ice nuclei; Growth of cloud drops; Growth of ice crystals; Curvature effect; Solution effect; Rain drop spectra; Precipitation mechanisms; Bergeron and Fendeisen process; Collision and coalescence processes;

Unit-III:

Solar Radiation: Solar radiation - heating and cooling rates of the atmosphere - latitudinal distribution of the radiation balances of the earth's surface, atmosphere and earth's atmosphere system. Characteristics of the sun; Nature of solar

radiation; Definitions and concepts in radiation; Transfer of radiation through a medium; Terrestrial radiation; Characteristics of terrestrial radiation; Absorption of terrestrial radiation; Transmission of terrestrial radiation through the atmosphere; Simpson's computation of terrestrial radiation transfer; Elsasser's radiation chart; Radiative cooling or heating of the atmosphere; The mean heat balance of the earth - atmosphere system; The atmospheric green house effect.

Measurement of Radiation: Angstrom electrical compensation Pyrheliometer, Eppley Pyranometer, Net Radiometer, Pyrgeometer.

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. An Introduction to Atmospheric Physics - David G. Andrews
6. G.W. Petty, A first course in atmospheric radiation, Sundog Publishing
7. J.M. Wallace, P.V. Hobbs, Atmospheric Science, 2nd ed., Academic Press
8. John A. Day, Vincent J. Schaefer, Roger Tory Peterson. Peterson First Guide to Clouds and Weather

M-104/PO-104: Dynamical Meteorology

Unit- I:

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

Unit- II

Continuity equation – Horizontal divergence, Vertical motion. Isobaric coordinate System - Transformation of momentum & continuity equations. Circulation & Vorticity – Bjerknes circulation theorem. Application to Land & Sea breeze. Vorticity equation. Potential vorticity - Application to Lee of the mountain trough, CAV Trajectories, Scale analysis of vorticity equation.

Unit- III

Atmospheric boundary layer: Atmospheric turbulence; Boussinesq approximation, 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

Text Books:

1. An Introduction to Dynamic Meteorology, J.R.Holton
2. Dynamical and Physical Meteorology, G.J.Haltiner and Martin
3. Dynamic Meteorology, B.Haurwitz
4. Dynamic Meteorology, Ed.Wiin Nielsen, WMO Publication

M-105/PO-105: Meteorology and Oceanography Computations

PART-A

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
   a. Potential temperature
   b. Equivalent temperature
   c. Equivalent potential temperature
   d. Lifting condensation level
   e. Equilibrium level
   f. Stability indices
8. Elsasser's Radiation chart: Flux determination

PART-B

1. Determination of Density using temperature and salinity.
2. Determination of Specific volume anomaly using S, T and D.
3. Stability and Richardson number.
4. Analysis of temperature data
   (a) Vertical profiles
   (b) Horizontal profiles
   (c) Identification of Upwelling and sinking
5. Determination of Heat budget parameters.
   (a) Latent heat
   (b) Sensible heat
   (c) Evaporation

M-106/PO-106: Observational Techniques (Practicals)

1. Measurement of atmospheric pressure by Fortin barometer, Kew pattern barometer.
2. Computation of 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. To calibrate a given thermistor for measurement of temperature.
6. Determination of wind direction and wind velocity at standard levels using Pilot balloon.
7. Measurement of Bulk SST and Skin SST.
8. Measurement of shortwave and Longwave radiation
9. Measurement of total columnar ozone, aerosol optical depth and precipitable water column
10. Automatic weather station- Measurements.
11. Current weather comparison
12. Cloud cover measurement

Syllabi for I Year – Second Semester

M-201/PO-201: Synoptic Meteorology

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, Weather charts and analysis.
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.

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.
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.

Unit-III:

Indian monsoons: Land and sea breezes – Definition of monsoon – 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. Northeast monsoon onset phenomenon and rainfall distribution.
Prediction of weather elements: Seasonal prediction of monsoon rainfall and date of onset. Maximum and minimum temperatures – Fog. Aviation Meteorology: SEGMET and Meteorological hazards to aviation – Take-off, landing, in-flight, - Icing, turbulence, CAT, visibility and fog.

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
8. Meteorology for Pilots by Mike Wickson
9. Manual of meteorology, part 2. Aviation meteorology / Bureau of Meteorology, Department of Science

M-202: Cloud Physics and Radar Meteorology

Unit-I:

Cloud physics : Cloud classification; Condensation nuclei; Ice nuclei; Growth of cloud drops; Growth of ice crystals; Curvature effect; Solution effect; Rain drop spectra; Precipitation mechanisms; Bergeron and Fendeisen process; Collision and coalescence processes; Measurement of Precipitation: Non-recording precipitation gauges, Recording precipitation gauges, Weighing Gauge, Float gauge. Tripping-bucket gauge, Optical rain gauge. Precipitation of warm and cold clouds; Cloud burst. Weather modification; Artificial stimulation of precipitation relevance of artificial rain making experiments in India; Hail formation; Hail suppression; Fog: Different types of fog formation and dissipation; Radar observation of clouds and precipitation.

Measurement of Humidity: Psychrometer, Hair Hygrometer, Dew point Hygrometer. Electrical Resistive and Capacitive Hygrometer, Hygrometer using absorption of electromagnetic radiation.

Unit-II:

Atmospheric optics: Mirages; Rainbows; Haloes: Atmospheric refraction; Coronas;
Atmospheric Electricity: Ionisation in the atmosphere; Fair weather electric field; Potential gradients; Conductivity; Conduction currents; Air-earth currents; Point discharge currents; Electrical characteristics of thunder storms; Theories of thunderstorm electrification; Tornadoes; Water spouts; Lightning discharges; Global air-electric circuit.

Atmospheric chemistry: Minor constituents; The sulphur compounds; The nitrogen compounds; The carbon compounds; Photo chemical pollution and smog with industrial application, Atmospheric aerosols; Rain out and wash out mechanisms.

Unit-III:

Special Profiling techniques for the boundary layer and the troposphere: Atmospheric boundary layer lidar development and applications. Sodars, Radio acoustic sounding system

Clear Air Radar: Medium frequency radar – gravity waves, ST and MST radar and wind profilers.

Doppler radar and Application – The weather radar precipitation estimation for cloud seeding, radar equation for precipitation targets. Velocity measurements,. Doppler weather radar-measurements and forecasting of tropical cyclones, thunderstorms and floods.

Text Books:

1. Cloud Physics by R.Rogers
2. Cloud, Rain and Rainmaking by B.J.Mason

3. Atmospheric Physics by J.V.Iribrane & H.R.Cho
4. Atmospheric Electricity by Chalmers
5. Electricity of the free atmosphere by Yaminganiton
6. The Physics of clouds by B.J.Mason
7. Technology Development for Atmospheric Research & Applications-B. Manikiam and T.G.K.Murthy, ISRO publications.
8. Radar hydrology for real time flood forecasting by R.J.Griffith, I.D. Clukiel, G.L.Austin and D.Han.
9. Radar in Meteorology by A. David
10. Doppler radar and weather observations by R.J.Doviak and D.S.Zrnic.

M-203/PO-203: Dynamical Oceanography

Unit-I:

The Geopotential structure of the sea – Concept of Geopotential, field of mass, field of pressure, determination of Geopotential anomaly, isobaric and level surfaces.

Stability of fluid column: vertical acceleration in fluids and criteria for static stability. Geostrophic currents: Barotropic and baroclinic fields, relative and slope currents, level of no motion, computation of relative currents in a two layer ocean and in stratified ocean, Bjerknes' circulation theorem and application to relative currents.

Unit-II:

Ocean circulation: wind induced currents, Ekman spiral, Up welling, sinking; equatorial current system, west ward intensification of currents, warm and cold currents of major world ocean, seasonal currents in North Indian Ocean, thermohaline circulation, T-S diagram and water masses.

Unit-III:

Fundamentals of waves and tides: wave characteristics, wave generation, sea and swell, deep and shallow water waves. Tide producing forces, equilibrium theory and tidal currents. Coastal Hazards- Storm surges and Tsunamis.

Textbooks

1. Introductory dynamic Oceanography by S. Pond and G.L. Pickard.
2. Elements of physical Oceanography by Mc Clellan.
3. Introduction to principles of dynamical oceanography by Neumann and Pierson.
4. Oceans by Sverdrup, Johnson and Fleming.
5. Fundamentals of Oceanography – Tomzoac and Godfrey

M –204/PO-204: Advanced Dynamical Meteorology

Unit- I:

Atmospheric energetics – Energy equation. Kinetic energy. Internal energy, Potential energy, Morgules theory of conversion of Potential & Internal energies to Kinetic energy. Available potential energy, CAPE, CINE. Expression for APE. General circulation of atmosphere – Maintenance of the mean circulation of kinetic energy balance of the atmosphere, Angular momentum consideration. Absolute vorticity consideration.

Unit- II:

Linear perturbation theory – Perturbation method. Properties of waves Sound waves, Gravity waves – External and Internal gravity waves, Rossby waves, Inertial waves, Geostropic adjustment process.

Unit- III:

Dynamics of tropical atmosphere: scale analysis of tropical motions, cumulus convection and convective heating, equatorial wave theory, Scale interaction in the tropics- wave number domain, frequency domain, Adiabatic potential vorticity.

Text Books:

1. An Introduction to Dynamic Meteorology, J.R.Holton
2. Introduction to Theoretical Meteorology by S.L. Hess
3. Tropical Meteorology, by T.N. Krishnamurti, WMO publication.
4. Dynamic Meteorology by B.W. Aikinson
5. Atmospheric and Oceanic Fluid Dynamics by Geoffrey K Vallis

M-205: Elements of General Meteorology (OD)

Unit-I:

State of the atmosphere : weather and Climate, Main constituents of dry air; Vertical thermal structure of the atmosphere; Environmental lapse rate; Standard atmosphere; Hydrostatic equilibrium; Hydrostatic equation; Geopotential; Equipotential surfaces.

Moisture variables- Absolute humidity, specific humidity, relative humidity, mixing ratio; Virtual temperature. Vertical stability of the atmosphere: Dry adiabatic lapse rate; Standard adiabatic lapse rate.

Unit II:

Radiation: Solar radiation, terrestrial radiation; mean heat balance of the earth - atmosphere system; atmospheric green house effect.

Fundamental and Apparent forces; Equations of motion; Geostropic wind, gradient wind, thermal wind.

Unit-III:

Circulation and systems: Land and sea breezes, thunder storms, tornadoes, dust storms; trade winds; ITCZ; Monsoons- Definition of monsoon, summer and winter monsoons over India, rain-bearing systems of monsoons; Tropical cyclones – Their structure and movement; Extra-tropical cyclones– their structure and movement; Air masses and fronts; Jet streams – Definition, jet streams affecting India. Impact of Global warming on Climate with special reference to India.

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. An introduction to Dynamic Meteorology – JR Holton
6. Monsoons – PK Das
7. Our weather – PA Menon

M-206/PO-206: Synoptic Analysis (Practicals)

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.

M –207/PO-207: Statistical and Numerical Methods using Fortran Programming (Practicals)

1. Correlation Coefficient and Linear Regression
2. Curve Fitting by the method of least squares
3. Multiple Regression
4. Analysis of Variance (ANOVA)
5. Auto correlation and Partial auto correlation
6. Gauss Siedel Iterative Method
7. Newton Raphson Method
8. Simpson's $1/3^{rd}$ Method
9. Runge Kutta 2^{nd} order method
10. Euler method for solving differential equation

Syllabi for II Year – Third Semester

M-301: Monsoon Dynamics

Unit -I:

Global perspective of monsoon, CTCZ, ITCZ over Indian ocean – structure and movement, 5-7 day, 30-50 day oscillations (MJO), 10-20 day oscillations.
Regional circulation systems: Jet streams and their characteristics, Easterly waves-structure and movement.

Monsoon variability: Interannual variability and decadal variability, Teleconnections of India summer monsoon with southern oscillation, El-Nino, La Nina, Indian Ocean dipole mode, NAO, Reversal of monsoon system, winter monsoon.

Unit -II:

Tropical cyclones: structure and mechanics – Life cycle, surface and upper air structures, budgets of momentum and energy, formation and movement – variability of hurricane intensity.

Thunder storms – CAPE and CINE, Favorable conditions for severe thunderstorms, influence of vertical wind shear, stability indices, Life cycle and structure of thunderstorm, Dust storm(Andhi), Kalabaisaki, Hail storm.
Tornadoes: Tornadoes in Indian subcontinent, structure of Tornado

Unit-III:

Monsoon rain bearing systems: Monsoon trough/ CTCZ, Depressions, onset vortex, Mechanism of formation, structure and dynamics, monsoon Mesoscale process, seasonal prediction and predictability of monsoon, coupled monsoon system, the role ocean in the life cycle of Indian monsoon system. ICRP programs with special reference to Indian Monsoon dynamics.

Text books:

1. Weather analysis and forecasting- Vol.1 and 2 by B.Petterson
2. Tropical meteorology by H. Reihl
3. Climate and Weather in tropics - H. Reihl
4. Climate and circulation of the tropics by S. Hasternath
5. Tropical Meteorology by G.C. Asnani.
6. Monsoon Meteorology P.K Das.
7. The physics of the monsoon R. N. Keshava Murthy and M. Sankar Rao
8. The Asian Monsoon- Bin Wang

M-302: Air Pollution Meteorology

Unit-I:

Sources and Classification of air pollutants: Sources of air pollutants, Factors affecting air pollution, Classification of air pollutants, air quality standards, and quality legislation. Scales of the air pollution problem: Local, Urban, Regional, continental and Global
Meteorology and air pollution: wind velocity, wind roses, turbulence, topographical effects, atmospheric stability, lapse rates, Inversions, Micrometeorological studies in Air pollution - Monin – Obrukhov length scale – diabatic conditions in the surface layer, surface layer models. Ekman-spiral characteristics, Urban Heat islands, Asian brown cloud, Forest fires. Detection of Aerosols.

Unit-II:

Transport and dispersion of air pollutants, estimating concentration from point sources, dispersion models, plume rise – plume rise for buoyant plume theories developed by Barryland, Cowen, Hol and Briggs, Plume rise in unstable, neutral, stable and calm conditions. plume behavior, ventilation stagnation
Effects of air pollution: Effects of air pollution on human health, animals, vegetation, materials and property. Air pollution Instrumentation Air sampling and analysis: Factors to be considered in sampling, ambient or atmospheric air sampling; methods of analysis, Procedure of analysis of gaseous pollutants in atmospheric air

Unit-III:

Global air pollution problems and programs: Acid rains. Air pollution management of an urban area – case studies for Indian urban centers – air pollution studies in India.
Modelling of Air Pollutants- Box Model, Gaussian Model, diffusion and dynamic models (point sources, line sources and area sources) Gaseous pollutants, Particle pollutants

Text Books:

1. Physico, Chemical aspects of Air pollution-Sinfield.
2. Physico, Chemical aspects of Air pollution-Henry.C Perkins.
3. Hand book of Applied meteorology – David D. Houghton (John Wiley & Sons, 1985)
4. Fundamentals of air pollution – A.C. Stern, RW Boubel, DB Turner and DL Fox. (Academic Press, 1984)
5. Air Pollution - A.C. Stern, (Academic Press, 1976)
6. Air pollution – Threat and Response - David A Lynn (Addison-Wesley Publishing company)
7. Fundamentals of air pollution – BSN Raju (Oxford & IBH Publishing Co. PVT. LTD, 1997)
8. Air Environment and Pollution – SS Purohit and Bhanu Kakrani (Agrobios (India), 2002)
9. Elements of air pollution and its control – T. Shivaji Rao (Vani Press, Visakhapatnam)

M-303: Numerical Weather Prediction

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 methods - Forward and centered finite difference methods, semi-implicit method - computational instability.

Unit-II:

Baroclinic Models - Two level model; Quasi-geostrophic multi-level models; Omega equation; Liner balanced model; Nonlinear balanced model, Baroclinic instability. Primitive equation models - Sigma coordinate system; Two level primitive equation model; Multilevel primitive equation models.

Introduction to mesoscale models: Nonhydrostatic assumption, basic structure of MM5 and WRF models and their applications.

Unit-III:

Objective analysis - Cressman method, Method of Optimum Interpolation. Initialisation ; Static initialisation; Dynamic initialisation- Normal mode initialisation, Newtonian relaxation or Nudging .

Nonlinear instability, Aliasing. Arakawa Jacobian. Staggered grid systems

Text Books:

1. Numerical Weather Prediction. G.J. Haltiner. John Wiley
2. Numerical prediction and dynamic meteorology. G.J. Haltiner and R.T. Williams. John Wiley.
3. Introduction to Dynamic Meteorology. J.R. Holton. Academic Press.
4. Numerical weather analysis and forecasting. P.D. Thompson

M-304/PO-304: Air – Sea Interaction

Unit-I:

The significance of Air-Sea Interaction; Atmospheric and Oceanic Interaction at various scales; Concept of Boundary Layer, Barrier Layer, Thermal inversion; Atmospheric Heat Budget; Variations of wind, temperature and moisture over the sea surface. Air sea temperature differences; Wind stress and resultant drag coefficient with variation to wind speed; Upper ocean boundary layer. Oceanic heat budget.

Unit-II:

Physical interaction between the ocean and atmosphere; Radiation, Heat exchange through latent and sensible heat; Oceanic forcing by air-sea exchange of moisture and heat; Momentum transfer and drag; Oceanic impact on the marine atmospheric circulation.

Unit-III:

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

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

M-305: Global Warming and Climate Change

Unit – I

The Climate system – Sun, Atmosphere, Ocean, Ice and energy balance of the earth.
History of climate change – glacial cycle (100, 000), interglacials, insterstadial events, year to decadal.

Greenhouse gases and global warming – GHGs trend, Global temperature trend, Global distribution of emissions, IPCC
Sources of CO_2 in the Land, Ocean and atmosphere

Unit – II

The history of climate and the human species, human-caused climate change, impacts of climate change on human well-being and the natural world, climate change-anthropogenic.

The Kyoto Protocol, Climate change –Extreme weather events, The Measurement of Climate Change, Global warming and the hydrological cycle, Climate change impact on ecosystems, Agriculture

Unit – III

Possible remedies of global warming – Reducing Carbon Emissions, Energy use and Emission trading, Future Emissions and Energy Resources, Current and Future sources of Methane, Biological sources of Nitrous oxide, Role of Scientist and Human being.

Text Books

1. Global Warming: A Very Short Introduction by Mark Maslin
2. Global Warming The Complete Briefing by John T Houghton
3. Intergovernmental Panel on Climate Change, (Cambridge University 2007)
4. Ruddiman, William F.2001. Earth's Climate: Past and Future
5. Henderson-Sellers, A., and P.J. Robinson, 1999. Contemporary Climatology (second edition). Prentice-Hall.
6. Houghton, J.T., 2001, (ed). Climate Change 2001, The Scientific Basis. 881pp.
7. Kuhn, T.S., 1962 and updates. The Structure of Scientific Revolutions (excerpts; no purchase necessary)
8. Contemporary Climatology, by Peter J. Robinson and Ann Henderson-Sellers.
9. Climate Change: A Multidisciplinary Approach, by William James Burroughs
10. Current trends in Global Environment by A.L. Bhatia (2005)

M-306: Numerical Weather Prediction (Practicals)

1. Computation of vorticity using geopotential height: Solution of Laplacian
2. Computation of advection : Solution of Jacobian
3. Relaxation for solution of barotropic vorticity equation
4. Preparation of computer code for (3) to obtain tendency field
5. Computation of surface fluxes
6. Numerical computation of LCL
7. Numerical computation of moist adiabatic
8. Computation of heating rates –Kuo scheme
9. Barotropic Instability
10. Baroclinic Instability
11. Cyclone track forecasting using Mesoscale models

M-307:Air Pollution (Practicals)

1. Wind observation in vertical
2. Temperature observation in vertical
3. Budyko index of turbulence-estimation
4. Finding of stability category for given data.
5. Estimation of ground concentration of conventional pollutants by Box model.
6. Estimation of ground concentration of conventional pollutants by Gaussian plum model
7. Estimation of ground concentration of conventional pollutants by working formulae
8. MODIS satellite data products

Syllabi for II Year – Fourth Semester

M-401: Satellite Meteorology

Unit-I:

Physical basis of remote sensing - Remote sensing of the environment with Electromagnetic energy - Atmospheric transmission, atmospheric window regions and absorption bands, Radiative Transfer equation. Remote sensing of atmospheric variables: Schwarzchild's Equation and its solution, Vertical sounding, Limb sounding, Detection of Aerosols.

Kepler's laws of universal planetary motion, Meteorological satellites and their orbital characteristics, Geostationary, Sun-synchronous, Polar and special purpose orbits, Different meteorological satellite systems- INSAT series, Meteosat series, NOAA series, TRMM and SSMI series, QUICKSCAT etc and future ISRO programmes - MEGHATROPIQUES satellite. Global weather satellite system.

Unit -II:

Satellite analogue data: Satellite image interpretation and enhancement techniques, cloud type identification and Neph analysis, Synoptic scale weather systems, Mesoscale weather systems, Tropical cyclones, Tropical cyclone categorization of different stages, Estimation of central pressure by using Dvorak's technique and extra tropical cyclones.

Satellite digital data: Retrieval techniques, SST, Cloud top temperature, methods of retrieval algorithms for temperature and humidity profiles, Cloud Motion Wind Vectors (CMWV), Quantitative Precipitation Estimation (QPE), Radiation Budget parameters from Kalpana-1 satellite.

Unit-III:

Tropical phenomena, Method of analysis of tropical disturbances, Mesoscale circulation patterns, Sea and land breeze circulations, orographic pattern; Application of satellite data for the study of southwest monsoon namely-onset of monsoon, active, break cycle, seasonal monsoon rainfall, low frequency oscillations.

Rainfall monitoring by VIS and IR data, Cloud Indexing Method, Bispectral techniques, Life History Techniques, Cloud Model Techniques, Active and passive microwave sensors and their application for Ocean surface winds, sea surface temperature, soil moisture, NDVI, Environmental Sensitivity Index (ESI). GPS sounding, receiver and data analysis.

Text Books:

1. Introduction to Environmental Remote Sensing - E.C. Barette and L.F. Curtis
2. The use of satellite data in rainfall monitoring- E.C. Barette and D.W. Martin

3. Remote sensing of atmosphere - J.T. Houghton, F.W. Taylor and C.D. Rodgess.
4. Satellite Meteorology - An introduction - S.Q. Kidder and T.H. Vanderhour
5. Introduction to Meteorological and other environmental satellites - WMO Publication
6. Remote sensing of atmosphere and Oceans - A Deepak
7. Training course on satellite meteorology techniques and applications - ISRO publication.
8. Lecture Notes for Post Graduate Course on Satellite Meteorology and Global Climate, Vols.1, 2 and 3. ISRO Publications.
9. Technology Development for atmospheric research and applications-ISRO publication, B.Manikiam and T.G.K.Murthy.

M-402: Dynamics of Climate Change

Unit – I:

The earth's changing climate: possible causes of climate change, natural Greenhouse effect-radiation balance, Importance of water, Greenhouse gases-Role of Carbon dioxide and Methane, Major uncertainties, recent trends in global warming. Greenhouse effect – global warming and rise in sea level, CO2 prediction models; Chlorofluorocarbons (CFCs) – depletion of ozone layers,
Carbon cycle: Physical and biological carbon pump, Marine and Terrestrial carbon cycle.

Unit – II:

Impact of climate change on weather parameters: Global and regional surface air temperature, Precipitation, snow, Ice, Water vapor, winds, Waves, geopotential height and Jet stream.

Impact of Climate change on Oceans: Sea surface temperature, Salinity, sea level, circulation, Conveyor belt, upwelling and ocean heat content.
Extreme events: Heat waves, Droughts, Floods, Thunderstorm and Tropical cyclones.

Unit – III:

Teleconnections: ENSO-Monsoon, Atlantic Multi-decadal Oscillation, Pacific Decadal Variability and other indices
Prediction and detection of climate variability and change: Estimate of global mean radiative forcing, direct and indirect effect of aerosols.

Detection and attribution of anthropogenic climate change, recent simulation of effects of increases in greenhouse gases
Depletion of Ozone layer due to Global warming, Programes: CLIVAR and IPCC.

Text Books:

1. IPCC Fourth Assessment Report (AR4). Climate Change 2007: The Physical Science Basis.
2. Frances Drake. Global Warming: The Science of Climate Change. Hodder Arnold Publication.
3. R.P. Pearce. 2002. Meteorology at the Millennium. Academic Press.
4. C. Donald Ahrens. Essentials of Meteorology. Thomson Brooks/Cole.
5. Houghton, John. 1997. Global warming: the complete briefing. New York/Cambridge: Cambridge University Press.

M-403: Climate Modelling

Unit-I:

General circulation and climate modelling: Introduction to climate modelling.
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.

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.

Unit-II:

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.

Unit-III:

Physics in general circulation climate models - Radiative Transfer, Boundary layer; Surface parameterization; convection; Large scale rainfall.

Regional climate models: Formulation; boundary conditions, specific applications.
Ocean modelling: Basic equations, wind driven barotropic models, simple thermohaline models, baroclinic models, mixed layer models.

Text Books:

1. Introduction to three dimensional general circulation models. W.M. Washington and Parkinson.
2. A Climate Modelling Primer. A. H. Sellers and K. McGuffie
3. Numerical prediction and dynamic meteorology. G.J. Haltiner and R.T. Williams. John Wiley
4. An introduction to three-dimensional climate modeling by Washington, Warren M. and Claire L. Parkinson
5. Atmosphere, Ocean and Climate Dynamics by John Marshall
6. Physics of climate by Peixoto P. Jose

M- 404: Agricultural Meteorology

Unit-I:

Agricultural meteorology - its scope and aims; crop microclimate; and soil and water, plants, farm animals (farm livestock), diseases and pests of crops and animals. Radiation and the surface energy balance and its components: the long-wave budget; surface radiation temperatures; total radiation budget and complete surface energy balance; Special aspects of radiation and temperature in agriculture. The soil and its heat balance - Transmission of heat in the soil; Diurnal and annual variations of soil; temperature and moisture; a model of soil temperature diurnal course at different depths.

Hydrometeorology: definition and scope, Storm modeling, Rainfall return periods, PMP models, Role of interception, infiltration, surface runoff, subsurface run flow, effect of snow, Heat transfer in the soil, turbulent heat transfer, water budget method- energy budget and aerodynamic methods,

Unit-II:

Rainfall-Runoff models, Flood forecasting, design floods Drought categories and assessment techniques, application of remote sensing techniques in soil moisture and drought monitoring studies. Effects of urbanization on climate and stream flow.

Water and the hydrological cycle in agriculture - Moisture characteristics of soils; Determination of water loss from land surfaces: fundamentals of the evaporation process, existing methods to determine evaporation, energy balance estimation of evaporation, aerodynamic estimation of evaporation; Combination" methods of Penman and others: development of the original Penman equation, evaporation formulae of Priestley-Taylor and Penman-Monteith; Special forms of precipitation: dew, snow; Soil moisture budgets - irrigation need.

Unit-III:

Relationship between weather, climate and agriculture; climatic requirements of common agricultural crops, Plant Phonology; effect of weather factors on the growth and development of plants and on quality and quantity; Weather factors conducive to infection; crop protection from adverse meteorological phenomena-droughts, heavy rains, storms, cold waves and frost, heat waves, shelter from winds. Artificial stimulation of precipitation; Hail: distribution of hail in space and time, active suppression of hail; Fire in vegetation;

Crop Weather calendars; statistical analysis of crop and weather data; Principles of weather data. Agro meteorological forecasting: basic principles, phonological forecasting, crop-yield forecasting, forecast and warning for agriculture. NDVI, remote sensing applications to agriculture, Climate change relating to agriculture. Principles of weather prediction for crops with special reference to India.

Text Books:

1. Hydrometeorology - C.J.Wiesner
2. Agro meteorology : G.Z.Venkskevitch, Israel Program for Scientific Transition, IPST press, Jerusalem, 300 pp., 1961
3. Guide to Agricultural Meteorological Practices: WMO No.134, 1981.
4. Lecture Notes for training Class IV Agricultural Meteorological personnel, WMO No.593, 1982.
5. Land use and agro system management under severe climatic conditions, WMO No.633, 1986.
6. Agroclimatic/Agrometeorological Techniques, S.Jeevananda Reddy, Jeevan Charitable Trust, ICRISAT Colony, Secunderabad, 1993

M-405: Applied Meteorology (Practicals)

Part-A

1. Handling of INSAT and NOAA data
2. Channel separation and corrections
3. Converting pixel values to brightness temperature (Bt)
4. Interpretation and applications of satellite images in conjunction with surface and upper air synoptic charts
5. Application of satellite cloud pictures for different synoptic systems
6. Estimation of intensity of tropical cyclone using Dvorak's technique
7. Retrieval of Sea Surface Temperature
8. Estimation of rainfall using infrared and microwave data
9. Diurnal variation of rainfall over Oceans

Part-B

1. Determination of average depth of precipitation
2. Evaporation and evapotranspiration models
3. Determination of the depth of precipitable water
4. Analysis of drought through water budget method
5. Stream flow analysis
6. River yields- water balance techniques
7. Soil heat flux
8. Soil temperature profile
9. Calculation of the bulk density of the soil and the total amount of soil water
10. Derivation of agro-climatic variables from weekly rainfall (R) and weekly potential evapotranspiration (PE).

Approved Course Pattern and Syllabi w.e.f. 2010-2011 academic year
Credit System in M.Sc. (Physical Oceanography)

I-Year First Semester

Course No.	Title of the Paper	Periods per week L	P	T	Internal assessment marks	Semester end examination marks	Total Marks	Credits
Theory:								
PO–101	Physical and Dynamical Climatology	4+1*	-	4+1*	15	85	100	4
PO–102	Physical Oceanography	4+1*	-	4+1*	15	85	100	4
PO–103	Physical Meteorology	4+1*	-	4+1*	15	85	100	4
PO–104	Dynamical Meteorology	4+1*	-	4+1*	15	85	100	4
Practicals:								
PO–105	Meteorology and Oceanography Computations	-	6	6	15	85	100	4
PO–106	Observational Techniques	-	6	6	15	85	100	4
PO–107	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	90	560	650	26

I-Year Second Semester

Theory:								
PO–201	Synoptic Meteorology	4+1*	-	4+1*	15	85	100	4
PO–202	Coastal Oceanography	4+1*	-	4+1*	15	85	100	4
PO–203	Dynamical Oceanography	4+1*	-	4+1*	15	85	100	4
PO–204	Advanced Dynamical Meteorology	4+1*	-	4+1*	15	85	100	4
PO-205	Elements of Physical Oceanography (OD)	4	-	4	15	85	100	4
Practicals:								
PO–206	Synoptic Analysis	-	6	6	15	85	100	4
PO–207	Statistical and Numerical Methods using Fortran Programming	-	6	6	15	85	100	4
PO–208	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	105	645	750	30

II-Year Third Semester

Theory:								
PO–301	Marine Instruments and Observational Techniques	4+1*	-	4+1*	15	85	100	4
PO–302	Indian Ocean Dynamics	4+1*	-	4+1*	15	85	100	4
PO–303	Ocean waves and Tides	4+1*	-	4+1*	15	85	100	4
PO–304	Air-Sea Interaction	4+1*	-	4+1*	15	85	100	4
PO-305	Coastal zone Management (OD)	4	-	4	15	85	100	4
Practicals:								
PO–306	Physical Oceanography	-	6	6	15	85	100	4
PO–307	Air-sea Interaction	-	6	6	15	85	100	4
PO–308	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	105	645	750	30

II-Year Fourth Semester

Theory:								
PO–401	Ocean Modelling	4+1*	-	4+1*	15	85	100	4
PO–402	Marine Acoustics	4+1*	-	4+1*	15	85	100	4
PO–403	Satellite Oceanography	4+1*	-	4+1*	15	85	100	4
PO–404	Estuarine Dynamics and Coastal Zone Management	4+1*	-	4+1*	15	85	100	4
Practicals:								
PO–405	Applied Physical Oceanography	-	6	6	15	85	100	4
PO–406	Dissertation	-	6	6	15	85	100	4
PO–407	Viva-voce	-	-	-	-	50	50	2
	Total	16+4*	12	28+4*	90	560	650	26
	Grand Total (1+2+3+4 semesters)	64+16*	48	112+16*	390	2410	2800	112

* Tutorial OD – Other Department

M.Sc. Physical Oceanography

Syllabi for I year – First Semester

PO – 101: Physical and Dynamical Climatology

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

PO-102: Physical Oceanography

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

PO – 103: Physical Meteorology

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

PO – 104: Dynamical Meteorology

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

PO – 105: Meteorology and Oceanography Computations (Practicals)

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

PO – 106: Observational Techniques (Practicals)

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

Syllabi for I year – Second Semester

PO-201: Synoptic Meteorology
[Common Syllabus with M.Sc. (Meteorology) Second Semester]

PO-202: Coastal Oceanography

Unit-I:

Waves in deep water, Waves in Shallow water, Transformation of waves in shallow water, Wave Breakers, Wave refraction, diffraction and reflection, Nearshore circulation: Longshore currents, rip currents, tidal currents.

Unit-II:

Sea levels: Long-term variations- Eustatic changes, isostatic changes, Short-term variations, Sea level rise and Global Warming; Coastal inundation, Extreme events: Storm surges, Tsunamis. Causes and mitigation.

Unit-III:

Beaches and Coasts: Divisions of the littoral zone, sediment movement in the littoral zone, Beach profiles, minor beach forms, short wave environment; Coastal classification, beach erosion and deposition, beach nourishment, sand spits, atolls; Coastal constructions: Jetties, groins, breakwaters, entrance channels etc.

Text books:

Beach processes and sedimentation by P.D. Komar
Beaches and coasts by C.A.M. King
Coastal Engineering by Horakiwa

PO – 203: Dynamical Oceanography
[Common Syllabus with M.Sc. (Meteorology) Second semester]

PO – 204: Advanced Dynamical Meteorology
[Common Syllabus with M.Sc. (Meteorology) Second Semester]

PO-205: Elements of Physical Oceanography

Unit-I

Physical properties of seawater: Temperature, Salinity and Conductivity, Density, Sound in the sea, Light in the sea, Colour of seawater. Temperature, Salinity and density distributions. Transparency of seawater.

Unit-II

Oceanographic Instruments: Temperature measurements; Protected and unprotected reversing thermometers, MBT, XBT, XCTD, CTD. Current measurements: Lagrangian and Eulerian methods with examples, Aandhera current meter, ADCP, Position fixing at sea, GPS. Wave and Tide measurements.

Unit-III

Waves, tides and currents: Deep water waves, shallow water waves, wave propagation, sea and swell waves; Types of tides, Sea level variations, Storm surges and tsunamis; Warm currents, cold currents, Longshore currents, rip currents and tidal currents.

Text books:

1. Introduction to Dynamic Oceanography by Pickard and Pond.
2. Elements of physical Oceanography by Mclellan.
3. Descriptive Physical Oceanography by M.P.M. Reddy

PO – 206: Synoptic Analysis (Practicals)

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

PO – 207: Statistical and Numerical Methods using Fortran Programming (Practicals)

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

Syllabi for II year – Third Semester

PO-301: Marine Instruments and Observational Techniques

Unit-I

Survey Instruments - Real Time Kinematic (RTK) GPS, Total station DGPS techniques, Auto level instruments; Marine meteorological instruments – Measurement of Wind, Atmospheric pressure and Humidity, Visibility, Sea surface temperature; Hydrographic Instruments – Echo sounder, XCTD, Sea Gliders, AVHRR, SAR, Multi spectral radiometers.

Unit-II

Platforms – Research vessels; Moorings - Surface mooring, Sub surface mooring, U type mooring; Satellites - Geo stationary and Polar orbiting satellites; Submersibles - Remotely controlled, Autonomous; Floats and drifters – Surface drifters, Sub surface drifters, ARGO floats.

Unit-III

Measurement of Dynamic Properties - Mechanical current meter, Electromagnetic current meter, Acoustic current meters, Acoustic Doppler Current profilers (ADCP); Wave measurements – Wave Rider; Tide gauges – Stilling well gauge, Pressure gauge; Remote sensors – Altimeter, Sea backscatter radar.

Text books

1. WMO Guide to Meteorological Instruments and Methods of observations. WMO – No. 8
2. http:// www.es.flinders.edu.au

PO-302: Indian Ocean Dynamics

Unit-I

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

Unit-II

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.

Unit-III

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

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

PO-303: Ocean Waves and Tides

Unit-I:

Wave hydrodynamics: wave characteristics, simple harmonic wave, Laplace equation, potential flows, Small amplitude wave theory - Airy's solution, Finite amplitude waves - -Stokes solution. Deep water waves and shallow water waves. Wave transformation. Wave celerity and particle orbits

Unit-II:

Wave generation: Jeffrey's theory, Sverdrup and Munk theory, wave growth and propagation. Group velocity.

Ocean tides: Tide producing forces, tide characteristics. Theories of tide generation: equilibrium theory, Dynamical theory. Prediction of tides by harmonic analysis. Renewable energy sources from Ocean – Wave energy, tidal energy and thermal energy OTEC.

Unit-III:

Wave forecasting: Sea and swell, significant wave height, wave spectrum. SMB method of wave forecasting, PNJ method of wave forecasting, Co-cumulative spectrum method, fetch limited and duration limited cases, swell forecasting, dispersion, angular spreading and the concept of wave forecasting filter.

Text books:

1. Coastal and Estuarine Dynamics by A.T. Ippen.
2. Elements of physical Oceanography by McClellan.
3. Observing and forecasting of ocean waves – H.Q pub. No. 603, US Navy.
4. Introduction to principles of dynamic oceanography my Neumann and Pierson

PO-304: Air-Sea Interaction

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

PO-305 : Coastal Zone Management

Unit-I

Waves, tides and currents: Deep water waves, shallow water waves, wave propagation, sea and swell waves; Types of tides, Sea level variations, Storm surges and tsunamis; Warm currents, cold currents, Longshore currents, rip currents and tidal currents.

Unit-II

Climate change and global warming: Sea levels, storm surges, tsunamis; Ocean resources: Potential fishing zones(PFZ), Gas hydrates, Harnessing of the Ocean Energy Resource: Ocean Thermal Energy Conversion (OTEC) plants, wave energy and tidal energy; Coastal constructions: Jetties, groins, breakwaters, maintenance of entrance channels etc.

Unit-III

Coastal zone management: Classification of Coastal Regulatory Zone (CRZ), Genesis of CRZ, Laws relevant for coastal zone management, prohibited activities, relevant legislations, Coastal security, Tidal flats, deltas, Maintenance of Aquaculture farms, Coastal meteorology: winds, aerosols, oil spills, coastal lows.

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

PO-306: 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
6. Observations of Shallow water waves and currents.
7. Estimation of MLD from T/S profiles
8. Thermal structure of the ocean from T/S profiles
9. Estimation of tides
10. Argo data analysis.

PO-307: Air-Sea interaction (Practicals)

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. Computation of rate of change in heat storage in relation to weak, normal and good monsoon conditions.

Syllabi for II year – Fourth Semester

PO-401: Ocean Modelling

Unit-1

Physical Modelling and Numerical (Mathematical) Modelling;
Uses of modelling, different methods and approaches in modelling, Diagnostic models, prognostic models.
Physics of Ocean modelling, Lagrangian and Eularian approaches in modelling, primitive equation models.

Unit-II

Model dimension and coordinates, Model domain, temporal and spatial resolution of the models.
Model initialization; Model forcing...

Unit-III

Shallow water equation, sub-grid scale parameterization, 4 dimensional data assimilation; Model validation; Indian Ocean boundary conditions, model forcing conditions over Indian Ocean.
Status of operational models in Indian Ocean – POM, MIKE21, ROMS, WAM etc.

Text Books:

1. Numerical models for Ocean Circulation – Pond S. and Bryan
2. Circulation models of Lakes and inland seas – T.J. Simons
3. WAMD1 Group, 1988; The WAM – a third generation ocean wave prediction model
4. Dynamics and modelling of ocean waves – Komen G.J and Cavaleri L.

PO-402: Marine Acoustics

Unit-I:

Concepts of absorption, scattering, attenuation, heat conduction, reflection and refraction of sound propagation in the sea.

Sound velocity vertical structure of the sea. Physical characteristics of the sea related to sound transmissions. Effect of internal waves on sound propagation
Acoustic Wave Equation – Normal mode theory and Ray theory.

Unit-II:

Transmission of sound in shallow waters, Transmission of sound in deep waters. Echosounder principle - Interpretation of Echosounding records

Unit-III:

Hydrological conditions of the Indian Ocean in relation to Acoustic propagation.
Sound velocity structure in the Northern Arabian Sea in relation to incursion of Persian Gulf water.

Sea Bottom characteristics in the Indian Ocean as related to sound propagation.

Text 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. Short term course on sound transmission in Sea - Lecture notes Dept. of E.C.E., I.I.Sc., Bangalore (1979).

PO 403: Satellite Oceanography

Unit-I:

Physical Principles of remote Sensing: Electromagnetic Spectrum, Wavelength regions, atmospheric window regions, black body radiation laws, Radiative transfer equation, Gaseous absorption and Scattering.

Satellite Orbits: Newton's laws, Kepler's laws, Orientation in space, Orbital elements, Orbit perturbation, Sun synchronous orbits, Geostationary Orbits, other Orbits.

Sensors for forecasting the Ocean: using the EM spectrum, ocean properties measurable from above, classes of sensors, seeing through the atmosphere.

Indian Remote Sensing Program with special reference to satellite Meteorology and Oceanography INSAT and OCEANSAT. Other satellites – NOAA, SEASAT.

Principles of Image Processing: Basics of image processing and Enhancement Presentation of Multi channel image data.

Unit- II:

Passive sensors: Visible wave band, thermal IR and microwave
Ocean colors and Remote Sensing: The coastal zone color scanner, Atmospheric correction of visible wave length data, Oceanographic interpretation of ocean colors and its applications in oceanography, Sea surface Temperature from infrared scanning radiometers, Characteristics of AVHRR, Atmospheric correction, cloud removal techniques. Retrieval of SST from AVHRR data, Potential uses of SST data.

Passive microwave radiometers: Physical principles, microwave emissivity of the sea surface, skin depth, effects of the atmosphere, and the geophysical model of the microwave radiation, salinity, and surface wind and SST retrieval
Comparison between infrared and microwave radiometers for SST measurement.
Air – Sea Interaction studies using satellite data.

Unit-III:

Active Sensors: Altimeter, Scatterometer and Synthetic Aperture Radar
Radars, sea surface roughness and Scatterometry: Measuring the radars energy reflected from the sea, microwave interaction with the sea surface, relationship between wind and radar back scatter, retrieving wind vectors from Scatterometer measurements, QUIKSCAT Scatterometer.

Radar Altimeters from the Ocean: Principles of Radar altimetry, distance measurement with a satellite altimeter, orbit determination, ocean currents from altimetry, estimating of wave height from the altimeter pulse shape, retrieving wind speed from return pulse amplitude, Application of altimetry.

Synthetic Aperture Radar imaging of Ocean: Principles of SAR operation, Ocean information from σo images, SAR imaging of ocean waves, shallow water bathymetry measured from SAR images.

Text books

1. Measuring the Oceans from Space by Ian S. Robinson
2. Satellite Oceanography- An Introduction for Oceanographers and Remote sensing scientists.
3. Satellite Meteorology an Introduction by Stanley Q. Kidder and Thomsas H. Vonder Haar.

PO-404: Estuarine dynamics and coastal zone management

Unit-I:

Classification of estuaries based on: Topography, Salinity, Stratification parameter, Stratification-Circulation diagram; Entrainment, Turbulence and Averaging: Characterization of flows, Mixing in stratified flows; Tides in estuaries, estuarine circulation and mixing, Hydrology and hydrography, sedimentation in estuaries.

Unit-II:

Salinity intrusion in estuaries: Basic factors governing salinity distribution, effects of salinity and fresh-water flow on tidal conditions, Internal flow processes; Coastal pollution: mixing and diffusion, dispersion of pollutants in estuaries; Tidal prism and Diffusion concepts in pollution analysis.

Unit-III:

Coastal zone management: Classification of Coastal Regulatory Zone (CRZ), Genesis of CRZ, Laws relevant for coastal zone management, prohibited activities, relevant legislations, Coastal security, Tidal flats, deltas, Maintenance of Aquaculture farms, Coastal meteorology: winds, aerosols, oil spills, coastal lows.

Text Books:

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

PO-405: Applied Physical Oceanography (Practicals)

1. Water Level Measurements in Estuary
2. Measurement of Tidal Currents
3. Wave Forecasting Methods
4. Analysis of sea level 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.
11. Estimation of Insolation at the Ocean surface using INSAT data
12. Estimation of Upwelling/Downwelling phenomena from ERS-1 Scatterometer data.