UNIVERSITY OF PUNE

Department of Atmospheric and Space Sciences

REVISED

Course Structure and Syllabi for

M. Tech. (Atmospheric Science)

September 2007

Background

The M.Tech. program in Atmospheric Science was started by the UGC in 1988 at the following universities : Andhra, Calcutta, Cochin and **Pune**. It wasa post- M.Sc. course and was put as a one and half year course. **A common syllabus was followed at all the four universities.**

University of Pune through Circular No. 204 of 1988 introduced the course as M.Tech. (Atmospheric **Physics**) It was named as Atmospheric Physics since the program was housed in the Department of Physics, although the syllabus was the UGC syllabus for Atmospheric Science followed by the other three universities.

The UGC had given three faculty positions for teaching this program which were taken over by the Government of Maharashtra under Atmospheric Sciences program.

The M.Tech. (Atmospheric Physics) course was revised and made as credit based syllabus through Circular No. 171 of 2003.

In 2003 the Management Council of University of Pune decided to transfer the three faculty positions of Atmospheric Sciences to Department of Space Sciences and rename it as Department of Atmospheric and Space Sciences.

Accordingly through Circular no. 55 of 2004 the following Statute Amendments were implemented.

Subject: Atmospheric Physics -- to --- Atmospheric Science.
Department of Space Sciences --to --Department of Atmospheric & Space Sciences.
BOS in Space Sciences -- to BOS in Atmospheric & Space Sciences.

From the academic year 2005-06 this course is being run in the Department of Atmospheric & Space Sciences.

Through Circular No. 222 of 2005 the M.Tech. syllabus was revised and the course was made into a two year course.

A revised syllabus for the M.Tech Atmospheric Science is being submitted and a few new topics have been added in keeping with the current research trends.

As the teaching of this course is done jointly done with Indian Institute of Tropical Meteorology (IITM), Pune, the syllabus has been revised through joint efforts between the scientists and teachers from both IITM and UOP.

Eligibility

1. Any M.Sc., with Physics and Mathematics as one subject at B.Sc. level. 50% Marks at the M.Sc. exam.

2. Any B.E./ B.Tech. **with one year experience in areas relevant to Atmospheric Science**. Physics and Mathematics as one of the subject at B.E./B.Tech. level. 50% Marks at the graduation level.

3. For reserved candidates the minimum marks at qualifying exam as per university rules.

Admission

- Ten students will be admitted to the course through a National level entrance examination.

  Students who are sponsored by the Indian Institute of Tropical Meteorology, Pune, under the MOU will be considered outside of these ten seats, and they need not sit for the entrance examination.

  Reservation of seats will be as per the rules of University of Pune.

Fees

- The tuition fees for the course will be Rs. 80/ per credit for students who are domiciles of Maharashtra. This fee is for the base year 2002-03 and the university rules on increase in the fees are applicable. The fees for students who are from other states and international students will also be as per university rules.

- In addition to the tuition fees a laboratory fees of Rs. 2000 per semester will be charged. This fees is for the base year 2002-03 and the university rules on increase in the fees is applicable. The other fees like development, library etc will be the same as charged by the university for Non-professional Course.

- Those students who are sponsored by IITM under the MOU will not have to pay the laboratory fees in the second year as long as the project is carried out at IITM.

Examination

- A student will have to complete 100 credits offered under this course to get the degree of M.Tech. (Atmospheric Science).

- A student is allowed to take a maximum of five credits from other allied courses like M.Sc. (Atmospheric/ Space Sciences), computational and simulation, geography, geology, environmental science etc. The course being opted can be taken only if it is approved by Head of Department and operational difficulties can be adjusted.

- Each credit will be for 20 marks. 10 marks for continuous assessment and 10 marks for final assessment. The continuous and final assessment together will form one passing head.

- Continuous assessment can be done through Seminars/ Assignments/ Oral test/ Written test.

- The final assessment for theory courses will be in the form of written examination for the whole course. As the courses are for smaller credits and if a particular course is completed well before the term ends then teacher concerned need not wait for the end of term examination to conduct the final assessment. The final assessment can be done in consultation with the Head of Department or Course Coordinator or the Chairman Examination Committee.

  However the result will be declared only after the end of term exams are completed.

- Examination procedure for Internship Training and Project are given in the detailed syllabus.

Backlogs

- The student has to clear at least 50% of the credits of the first year before he can be allowed to take admission for the second year courses.

- If the student has a backlog course then he/she can improve the continuous assessment marks of that course only when the course is being run and he/she will be required to register for that course and attend the classes.

M.Tech. (Atmospheric Science)

COURSE STRUCTURE

Course No.	Course Title	Credits
	FIRST YEAR {Semesters I and II}	
ATM-01-T	Introduction to Weather and Climate	2
ATM-02-T	Mathematical and Statistical Methods	3
ATM-03-T	Observational Techniques	2
ATM-04-T	Satellite Meteorology	1
ATM-05-T	Atmospheric Thermodynamics	2
ATM-06-T	Radiation	1
ATM-07-T	Cloud Physics and Atmospheric Electricity	2
ATM-08-T	Atmospheric Chemistry	2
ATM-09-T	Atmospheric Dynamics-I	2
ATM-10-T	Atmospheric Dynamics- Circulation & Vorticity	2
ATM-11-T	Atmospheric Waves and Instability	3
ATM-12-T	Dynamics of Oscillation	1 *
ATM-13-T	Dynamics of Monsoon	1 *
ATM-14-T	Elements of Atmospheric Modelling	1
ATM-15-T	Mesoscale Modelling	2 *
ATM-16-T	Fluid Dynamics- Basics	1
ATM-17-T	Boundary Layer and Turbulence	3
ATM-18-T	Dynamics of Ocean Circulation	1
ATM-19-T	Atmospheric Energetics and General Circulation	2
ATM-20-T	Climate Change and Modelling	2
ATM-21-T	Numerical Weather Prediction	2 *
ATM-22-T	Objective analysis, Initialization and Parameterization	2
ATM-28-T	Agrometeorology	2 *
ATM-29-T	GIS and its application	1 *
ATM-30-T	Air Pollution	2 *
ATM-31-T	Hydrometeorology	2 *
ATM-23-L	Chart Analysis	2
ATM-24-L	Numerical Analysis and Computer Programming	3
ATM-25-L	Computations in Dynamic Meteorology and NWP	5
	SECOND YEAR {Semesters III and IV}	
ATM-26-P	Internship Training	10
ATM-27-P	Project	40

*** Optional Courses**

Each Credit is of 15 Contact Hours in the form of Lectures/ Tutorials/ Seminars.

T- Theory; L- Lab work; P- Project/ Training

Detailed syllabus is given in the Annexure-I

Annexure-I

Detailed Credit Wise Syllabus for M.Tech. (Atmospheric Science)

ATM-01-T: Introduction to Weather and Climate [2 Credits]

Atmosphere and its constituents, Synoptic observations- surface and upper air
Preparation of weather charts and their analysis

Diurnal variation of temperature, pressure, relative humidity, clouds etc.
Tropical meteorology : Easterly Waves, ET-ITCZ, Inversion.
Extratropical Meteorology: Air mass, Fronts- Frontogenesis and Frontolysis, Extratropical Cyclones and Anticyclones, Jet Streams
Synoptic systems in different seasons. Winter - Western disturbance, Rossby Waves, Westerly Jet Stream, Fog, Cold Wave etc.. Summer - Thunderstorms, Dust storms, Heat wave, Cyclonic disturbances. Monsoon - Onset, Activity, Withdrawal, Breaks, Depressions, Easterly Jet Stream. Post Monsoon - Cyclones in the Indian Seas, N.E. Monsoon.

Global Climatology - Global distribution of pressure and temperature at m.s.l. in winter and summer, distribution of annual rainfall and its variability, distribution of moisture and clouds. Vertical distribution of temperature. General circulation of atmosphere. Development of monsoons. Major categories of world climates.

Indian Climatology - Different seasons. Distribution of Means Sea level pressure/temperature in different seasons. Wind circulation and temperature distribution over India in lower, middle and upper troposphere in different seasons. Indian rainfall in different seasons. Indian summer monsoon, onset, withdrawal, rainfall distribution, inter annual variability of monsoon. Main synoptic pressure systems causing weather over India in different seasons.

Books for ATM-01-T

1. Atmosphere, Weather and Climate R.J. Barry and R.G. Chorley (Methuen Publication)
2. General Climatology" Critchfield
3. South West Monsoon" by Y.P. Rao (IMD Publication) .
4. An Introduction to Meteorology by S. Pettersen
5. Elements of meteorology by Miller, Thompson and Paterson
6. General Meteorology by H.R. Byer
7. Monsoon by P.K. Das
8. Tropical Meteorology by T.N. Krishnamurthy
9. Tropical Meteorology by Riel.
10. Tropical Meteorology Vol 1, 2, 3, by G.C. Asnani

ATM-02-T : Mathematical and Statistical Methods [3 Credits]

Module-1
Fourier series, Finite Differences, Methods of obtaining eigen values, eigen vectors.
Transform: Laplace, Fourier and Wavelet
Complex variables, Residue, Contour Integration and application of complex variables to the study of dynamical instabilities in the atmosphere.
Partial Differential Equations, Bessel functions, Legendre Polynomials, Spherical harmonics,

Finite difference equivalents of first and second order differential coefficient in atmospheric physics, analysis of computational errors.

Module-2 Auto-correlation theory, standard statistical distributions

(Normal, binomial, gamma, students, t, χ^2). Application of
Auto-correlation and auto regressive processes applied to monsoon rainfall data.
Error Analysis, Sampling and Test of Hypothesis, Analysis of variance

Module-3 Interpolation and extrapolation techniques, Grid-point interpretations, errors of space time differencing schemes. Numerical solution of Partial Differential Equations. Harmonic Analysis and Spectral Analysis, Numerical Integration schemes.

Books for ATM-02-T

1. Partial differential equations of Mathematical physics ", Vol. 1 by A.N. Tychonov and A.A. Samarski (S. Radding Holdenday Inc.).
2. Numerical Analysis - the mathematics of computing ", Vol. 1 and 2, W.A. Watson, T. Philipson and P.J. Oates (Edward Arnold Publication).
3. Time Series Analysis and Forecasting" O.D. Anderson (Butterworths Publication)
4. Numerical Methods in Engineering" Mario G. Salvadore and M.L. Baran.
5. Applied Mathematics for Scientists and Engineers by Pipes
6. Partial Differential Equations by Ralston and Wilf
7. Numerical Methods used in Atmospheric Models" WMO GARP-17.
8. Dynamic Meteorology and Numerical Weather Prediction" G.J. Haltiner and R.T.Williams, John Wiley and sons,
9. Numerical Analysis by Shastri

ATM-03-T Observational Techniques [2 Credits]

Module-I

Conventional measurements of pressure, temperature, humidity, wind, precipitation, visibility, clouds, soil temperature and humidity. Ocean temperature, salinity, wave height, currents. Self Recording instruments, Radiosondes, Radiometersondes, Ozone sonde.

Module-II,

LIDARS, SODARS, Weather RADARS, Remote-sensing techniques (WP-RASS). Measurements of Particulate matters, SO_x, NO_x, CO_2 and CO.

Books for ATM-03-T

1. Probing the atmospheric boundary layer , D.H. Lenschow
2. Instruments and Techniques for probing the atmospheric boundary layer D.H. Lenchow.
3. Guide to Meteorological Instruments and method of observation" WMO-8,
4. Meteorological Instruments" W.E.K.Middleton and A.F. Spilhaus,
5. Applications of Remote Sensing to Agrometeorology F.Toselli, Kluwer
6. Radar Meteorology by L.J. Batton

ATM-04-T Satellite Meteorology [1 Credit]

Polar orbiting and Geostationary satellites, Satellite systems: IRS and INSAT Meteorological Images Multi-channel sensing, measurements of atmospheric temperature, humidity, CO, Ozone, Clouds, Soil temperature and moisture, sea surface temperature, sea waves, ocean bed topography, future prospects.

Books for ATM-04-T

1. Theory of Satellite Orbit in the Atmosphere by King Hele
2. Numerical Analysis by Shastri
3. Weather Satellite by L.F. Hubert
4. Meteorological Satellite by W.K. Widger
5. A guide to Earth Satellite by D. Fishlock
6. Advances in Satellite Meteorology by Vinnichenko Goralik
7. Satellite meteorology by Henri W. Brandli
8. Satellite Meteorology - WMO Technical Notes No. 124 and 153.
9. Satellite Meteorology, by R.R. Kelkar

ATM-05-T Atmospheric Thermodynamics [2 Credits]

Structure and composition of the atmosphere, Equation of state for dry and moist air , Adiabatic and Isothermal Processes, Humidity Parameters, Virtual Temperature, Standard Atmosphere, Barometric Altimetry, Laws of thermodynamics, Entropy, Potential Temperature, Pseudo- adiabatic Process, Equivalent Temperature, Equivalent Potential Temperature, Claussius – Clapeyron Equation, Stability and Instability, Parcel Method and Slice Method , Entraiment in Cb clouds, Thermodynamic Diagram: p, α – diagram, Emagram, T - ϕ gram, Uses of thermodynamic diagrams, Precipitable Water Vapor, Rate of Precipitation, Role of Convective Available Potential Energy (CAPE) and Convective Inhibition Energy (CINE) in thunderstorm development

ATM-06-T Radiation [1 Credit]

Radiative Transfer in the Atmosphere- Temperature of the Sun and spectral distribution of solar radiation, long wave radiation, black body radiation budget of radiation energy. Passage of solar radiation through the atmosphere, Atmospheric Windows, emmisivity, Absorption spectra of atmospheric gases, optically thick and thin approximations, aerosol scattering, calculations of radiative heating and cooling. Terrestrial radiation and its passage through the atmosphere. Raleigh and Mie scattering. Role of atmospheric dust in radiation balance, effect of volcanoes.

ATM-07-T Cloud Physics & Atmospheric Electricity [2 Credits]

Atmospheric aerosols: Continental and Marine (Origin, Physical and Chemical characteristics), Cloud Morphology, Warm Cloud Microphysics (Nucleation and Condensation), Growth of cloud droplets by collision and coalescence, Cold Cloud Microphysics (Nucleation and growth of ice), Ice in the atmosphere.
The electrical structure of thunderstorms, Cloud electrification mechanisms, Physics of lightning, lightning and nitrogen fixation.
Atmospheric electricity in fair weather (Ions and Atmospheric conductivity, Space charges), Electric field, Air-Earth currents, Precipitation currents and Point discharge currents. Global Electric Circuit (Classical concept, validity and limitations).
Weather modification (Artificial and inadvertent).

Books for ATM-05-T, ATM-06-T and ATM-07-T

1. Introduction to Theoretical Meteorology" S.L.Hess,
2. A Short course in cloud physics" R.R. Rogers,
3. Physical Meteorology" H.G. Houghton.
4. Atmospheric Sciences: An introductory Survey" J.M. Wallace and P.V. Hobbs, Academic Press.
6. Atmospheric Electrodynamics" H.Volland, Springer Verlag,

7. An Introduction to Atmospheric Thermodynamics by A.A. Tsonis , Cambridge
8. Physics of the Cloud by B.J. Mason
9. Microphysics of cloud and Precipitation by Pruppacher and Klett
10. Atmospheric Electricity by J.A. Chalmers
11. Earth's Electrical Environment- National Academy Press
12. Physical Meteorology by J.C. Jhonson
13. Lightning by M.A. Uman
14. Cloud Dynamics by R.A. Houze
15. Clouds Rain and Rainmaking by B.J. Mason
16. Electrical Nature of Storms by D. McGorman and W.D. Rust

ATM-08-T Atmospheric Chemistry [2 Credits]

Chemistry of the atmosphere : Evolution of earth's atmosphere, Nitrogen, hydrogen halogen, sulfur, carbon-containing compounds in the atmosphere, ozone and neutral chemistry, chemical and photochemical processes, Chemical and dynamical life time of atmospheric constituent.

Ozone in the Atmosphere: Evolution of the ozone layer, sources and sinks of tropospheric and stratospheric ozone, chlorofluorocarbons, ozone and UV-radiations, supersonic transport.

Atmospheric aerosols: Concentration and size, sources, and transformation, Chemical composition, transport and sinks, residence times of aerosols, geographical distribution and atmospheric effects.

Air Pollution : Sources of anthropogenic pollution, Atmospheric effects- smog, visibility

Books for ATM-08-T

1. Introduction to Atmospheric Chemistry by P.V. Hobbs
2. Atmospheric Chemistry and Physics : From Air Pollution to Climate Change by John H. Seinfeld, Spyros N. Pandis
3. Chemistry of the Upper and Lower Atmosphere by Barbara J. Finlayson-Pitts, Jr., James N. Pitts.
4. Chemistry of Atmospheres by Richard P. Wayne.
5. Basic Physical Chemistry for Atmospheric Sciences by P.V. Hobbs

ATM-09-T Atmospheric Dynamics-I [2 Credits]

Equations of motion in spherical co-ordinates, rotating frame, Coriolis force, quasi-static approximation. Energy and angular momentum consistency of quasi-static approximations, Scale Analysis, Rossby number, Natural Co-ordinate System, Trajectory and Stream lines Blatons Equation, balanced flow- Geostrophic Flow, Inertial Flow, Cyclostrophic Flow and Gradient Flow. Equations of continuity in spherical and cartesian co-ordinates. Thermodynamic energy equation, Pressure as vertical co-ordinate and Basic equations in Isobaric Coordinates. Generalized vertical co-ordinates.

Differential Properties of wind Fields Translation, Divergence, Rotation and Deformation., Diffential equation for stream lines Vertical Variation of Winds Thermal Wind , veering and backing, hodograph Kinematics of Pressure Fields: Intensification and Weakening: Deepening and Filling.

ATM-10-T Atmospheric Dynamics-Circulation & Vorticity [2 Credits]

Circulation, vorticity, divergence, Stokes Theorem, Divergence Theorem , Circulation theorems – Kelvin's Theorem and Bjerknes Theorem and applications of Circulation theorems – Sea Breeze and Land Breeze; General Circulation. Solenoidal Vector, Barotropic and baroclinic fluids. Helmholtz theorem for split of horizontal wind vector. Vorticity and divergence equations, Scale Analysis, Balance Equation, split of vorticity and divergence equations into rotational and irrotational terms.

ATM-11-T Atmospheric Waves and Instability [3 Credits]

Module-I, Perturbation Theory, Atmospheric waves, Phase velocity, Group Velocity, Dispersion, Sound waves, Gravity waves, Inertial Waves Rossby waves, Haurwitz Rossby waves

Module-II, Atmospheric Waves and Instabilities: Wave motion in general, phase and group velocity, momentum and energy transports by waves in the horizontal and the vertical. Log-Pressure Coordinate System, Equatorial Beta plane Approximation. Atmospheric Kelvin and Mixed Rossby Gravity Waves. Dynamical Instabilties, Barotropic Instability, Baroclinic Inertial instability, Necessary condition of Barotropic and Baroclinic instability. . Kelvin - Helmholtz Instability.

ATM-12-T Dynamics of Oscillation [1 Credits]

Stationary Waves: Mountain waves, Lee waves, Stationary planetary waves, Southern Oscillation, El Nino, La Nina, 5 day Oscillation, Quasi Bi-weekly Oscillations, QBO, Madden Julian Oscillation. Vertical propagation of wave energy, Energetics of lower stratosphere, Vertical coupling of the troposphere and stratosphere, stratospheric warming, blocking situations in the troposphere.

ATM-13-T Dynamics of Monsoons [1 Credit]

Large-scale organization, Dynamics of ITCZ and double equatorial trough. CISK, dynamics of easterly waves, monsoon depressions and tropical cyclones, variability of monsoon.

ATM-14-T Elements of Atmospheric Modeling [1 Credit]

Laboratory simulation, Principles of dynamical similarity, laboratory simulation of some atmospheric phenomena like general circulation, monsoon flow, tornadoes etc.. Elements of numerical modelling of Atmospheric phenomena

Books for ATM-09-T, ATM-10-T, ATM-11-T, ATM-12-T, ATM-13-T, ATM-14-T

1. An Introduction to Dynamic Meteorology" J.R. Holton, Academic Press.
2. Dynamic Meteorology" Askel Wiin Nelson, WMO Publication.
3. Introduction to Theoretical Meteorology" S.L. Hess,
4. Dynamic and Physical Meteorology" G.L. Haltiner and F.L. Martin, Mc Graw Hill.
5. Ceasless Wind by Dutton
6. Weather Forecasting Vol I and II by S. Pettersen
8. The Physics of the Atmosphere by Houghton
9. Tropical Meteorology by T.N. Krishnamurti
10. The Physics of Monsoons R.N. Keshava Murthy and M.Shankar Rao, Allied Publishers, 1992.
11. Tropical Meteorology - Vol I, II and III G.C. Asnani,
12. Monsoon Meteorology Chang and Krishnamurthy
13. Monsoon by P.K. Das
14. Atmospheric Waves by Tom Beer
15. A course on Dynamic Meteorology, by N. Pandarinath

ATM-15-T Mescoscale Modelling [2 Credits]

Definition of meso α, β, γ scale.
Basic set of equations (for mesoscale meteorological simulations), Computation of Tensor analysis. Synoptically induced circulation. Thermally induced circulation. Free atmosphere circulation (non convective and convective circulation).
Types of Models- Physical Models, Mathematical Models.
Formulation of mesoscale numerical models.
Assimilation and initialization of Atmospheric data for mesoscale modeling.
Forecasting and nowcasting mescoscale phenomena.

Books for ATM-15-T

1. Mesoscale Meteorological Modelling by Roger A. Pielke
2. Mesoscale Atmospheric Circulation by B.W. Atkinson
3. Mesoscale Meteorology and Forecasts edited by P.S. Ray

ATM-16-T Fluid Dynamics- Basics [1 Credit]

Continuum Hypothesis, Lagrangian and Eulerian frames of references, ideal fluid, rotational and irrotational motion, velocity potential, stream function, two dimensional potential flows, Bernoulli's equation, viscous fluids, Rossby number.

ATM-17-T Boundary layer and Turbulence [3 Credits]

Module-I,
Boundary Layer General properties of boundary layer, Navier Stokes equation, Boussinesq Approximation, Energy dissipation, Reynolds number, Froud number,convective PBL, Neutral PBL, Stably-stratified PBL, Surface layer, Ekman layer, Similarity theories and resistance laws, effects of baroclinicity, Non-stationarity and horizontal inhomogeneity, Tropical boundary layer, urban boundary layer.

Module-II
General Turbulence theory and Non linear Dynamics Stability of flow, isotropic turbulence, geostrophic turbulence, velocity-velocity correlations, fully developed turbulence, Kolmogorov and Obukhov scaling relations. Quasiperiodic flow and frequency locking, Strange Attractors and chaos, Different routes to chaos.

Books for ATM-16-T, ATM-17-T

1. "Fluid Mechanics" L.D. Landau and E.M. Liftshifts, Pergamon Press.
2. "Atmospheric Turbulence" Panofsky and J.A. Dutton.
3. "Introduction to Boundary Layer Meteorology" Stull
4. "The Atmospheric Boundary Layer" R.M. Stewart, WMO-523.
5. "Atmospheric Pollution" F.A. Pasquill.
6. "Micro meteorology" O.G. Sutton.
7. Micrometeorology by S.P. Arya, Academic Press

ATM-18-T Dynamics of Ocean Circulation [1 Credit]

Earth and Ocean basin- Geometry of ocean basin, bottom topography, oceanography data collection.
Elements of Ocean Circulation Surface wind stress, Ekman layer dynamics, Geostrophic flow in Ocean -Ocean currents, Wind driven ocean circulation, Thermohaline circulation, Mixed layer circulation. Thermodynamics and energy relations in Ocean,

Sea water composition, vertical profile of temperature and salinity in the three major oceans, Basic concepts of waves and Tides in Ocean, Ocean currents. Scales of ocean motion.

Books for ATM-18-T

1. "Principles of Ocean Physics" J.R. Apel, Academic Press.
2. "Atmospheric Ocean Dynamics" A.E. Gill, Academic Press.

ATM-19-T Atmospheric Energetics- General Circulation [2 Credits]

Time mean fields and other statistics of observed general circulation; zonally symmetric and asymmetric components; mean-meridional circulation and eddies; Walker circulation. Maintenance of zonally mean circulation and eddies. Energetic of the atmosphere- Available Potential Energy; Kinetic Energy, Budgets of A_E ,K_E and K_z . Conservation of angular momentum. Atmospheric Energy cycle.

Books for ATM-19-T

1. "The nature and theory of General Circulation of the atmosphere " E.N. Lorenz WMO Publication.
2. "The Global Circulation of the Atmosphere" Edited By G.A. Corby, Royal Meteorological Society.
3. "Climate and Circulation of the Tropics" by S. Hastenrath, D.Ridel Publishing Company.
4. Tropical Meteorology" by T.N. Krishnamurthy, WMO Publication.
5. Global Atmospheric Circulation " by Richard Grotfahn, Oxford University Press.
6. Fundamentals of Atmospheric Energetics " by Askel Wiin Nelson and Tsing-Chang Chen, Oxford University Press.
7. Dynamic Meteorology" A. Wiin Nelson, WMO Publication.
8. Piffer Lecture Series - IITM
9. General Circulation by Stewart WMO Publications
10. Climates of South Asia by G.B. Pant and Rupa Kumar

ATM-20-T Climate change and modelling [2 Credits]

Module- I

Definition of Climate Long term changes (Climate of Past century, past millennium, past glacial period). The ice age and glacial chronology. Methods of determining past climate. Possible causes of climate change- External (Milankovitch variation and Solar activity) and Internal (natural and anthropogenic**)**. General idea of internal dynamical processes of the atmosphere, oceanic processes, Cryospheric processes, land processes. Basic Radiation processes. Climate feedback mechanism.

Module- II

Climate Modelling - Definition of Climate Models, Simple climate model- 0 - D models, 1 – D climate models Energy balance models and sensitivity studies, Radiative Convective model. Two dimensional climate model. Ocean-Atmosphere interaction and simple Ocean-Atmosphere coupled models. General Circulation Climate Models- Dynamics and Physics of General Circulation Climate Model. Land Surface parameterization in General Circulation Climate Model. Simple models of El-Nino and Southern Oscillations.

Books for ATM-20-T

1. Physical Climatology by W.D. Sellers
2. Foundation of Climatology by E.T. Stinger
3. Climate-Past, Present and Future Vol-I and II by Lamb
4. An Introduction to Climate by G.W. Threwartha
5. The nature and causes of climate change by Goodies, Paultikaf and Davies
6. Science of Climate Change IPCC, Cambridge
7. Climate of South Asia by G.B. Pant and Rupa Kumar
8. Climate System Modelling by Trenberth K.E.
9. The Physical Basis of Climate and ClimateModelling- WMO-GARP, No. 16
10. Three Dimensional Climate Modelling by Washington and Parkinson.
11. Climate Modelling Primer Henderson Sellers and McGuffie

ATM-21-T Numerical Weather Prediction [2 Credits]

Numerical Weather Prediction Historical Back ground, Finite Difference Schemes for Space and Time, Trucation Error, Laplacian and Jacobian, Linear and non-linear computational instabilities, Staggered Grid, Aliasing, Arakawa Jacobian, Barotropic and Equivalent Barotropic Models, Relaxation Methods- Simultaneous and Sequential Relaxation, Under and Over Relaxation, Solution of Poisson's Equation by Relaxation Method, Thermodynamic Energy Equation and Quasigeostrophic Vorticity Equation in Isobaric Coordinates, Diagnostic Omega Equation, Tendency Equation and Potential Vorticity Equation, Two Parameter Baroclinic Model, Primitive Equation Model, Sigma Coordinate System and Primitive Equation Model in Sigma Coordinate system , Spectral Model.

ATM-22-T Objective analysis, Initialization and Parameterization [2 Credits]

Basic concepts of Objective analysis and Initialization- Static, Dynamic, normal mode and 4-D data assimilation.

Introduction to Parameterization – Convective Adjustment Scheme, Kuo's Cumuluis Parameterization, Arakawa Schubert Parameterization, Radiation Parameterization- Solar Radiation and Terrestrial Radiation, Boundary Layer Parametrizartion Scheme

Books for ATM-21-T, ATM-22-T

1. "An introduction to Dynamic Meteorology" by J.R. Holton, Academic Press.
2. "Numerical Methods used in Atmospheric Models" WMO-GARP Series No.17
3. "Numerical Prediction and Dynamic Meteorology" G.J. Haltiner and R.T. Williams,
4. "Parameterization of subgrid scale processes" WMO-GARP, Series No. 8.
5. Numerical Weather Prediction by P.D. Thompson

ATM-28-T Agrometeorology [2 Credits]

Module-I Solar radiation and crop:
Green leaf response to spectral radiation components, solar spectra and plant processes. Meteorological factors in photosynthesis: diffusion process, photochemical process, biochemical process, solar radiation and photosynthesis. Role of CO_2 concentration and turbulence in photosynthesis. Effects of temperature and moisture in plant growth. Soil temperature, thermal properties of soil, soil temperature and crop yield, heat transfer from plant leaves, damage due to freezing temperature and high temperature for crops. Concept of Growing Degree Days (GDD).Soil moisture, water stress and plant Development. Evaporation transpiration, Evapotranspiration.

Module- 2. Rainfall characteristic, Soil and crop growth:
Soil water balance, Radiation balance, climatic normal for crop and live stock production. Crop yield forecast model, modeling crop growth and production. Rainfall Climatology for Agricultural planning, sowing dates, Moisture Availability Index (MAI) and Assured rainfall drought, classification, Analysis. Climate change and crop production weather forecasting for Agriculture. Crop weather calendar, Effects of Pest and diseases in Agriculture production.

Books

1. Hand book of Agricultural Meteorology
   Edited by John .F.Griffiths
2. Drought Management on Farmland by J.S Whitmore Kluwer Academic Publisher
3. Introduction to Agrometeorology by H.S.Mavi

ATM-29-T GIS and its application [1 Credit]

Components of GIS: Computer system and software, spatial data, Thematic characteristics of spatial data various sources of spatial data.

Spatial data modeling: data structure, Raster data Structure, vector data structure. Digital terrain modeling.

Data base management, data input and editing, data analysis, map overlay. Application of GIS in Agriculture, forestry ,snow mapping, etc.

Books

1. An introduction to Geographical Information System by Ian Heywood, Sarah Cornelius and Steve Carver
2. An introduction to Geographic Information Systems by Kang-tsung Chang

ATM-30-T Air Pollution [2 Credits]

Definition, Types of Pollutants (gaseous, particulate matter) Sources of pollutants (point, area ,volume) Forest fires ,Industrial sources etc. The atmosphere: over land and oceans, different regions of the atmosphere and pollutants terrain, the PBL and its significance. Qualitative geometry of pollutions the stability of atmosphere and its role in pollution.

Dynamics of ABL, Equation of motion, Prandtl's Theory of mixing layer, Turbulence, convection ,Richardson Number. K-Theory of Diffusion, Relative and Particle Diffusion -Taylor Theory

The Plume puff and continuous Plume, Rise of Plume in different environment, Entrainment, Theory of Plume rise. The Gaussian Plume and modeling of Plume dispersion. Brownian motion, random walk and Turbulent theory of diffusion

Some aspects on modeling diffusion: physical and numerical.

Books

1.O.G.Sutton, Micrometeorology
2. F.Pasquill, Atmospheric Diffusion.
3. Stull, Boundary layer Meteorology
4 Briggs.G.A , Plume Rise
5 Arya P.S , Atmospheric Boundary Layer
6.Panofsky and J.A.Dutton Atmospheric Turbulence
7. Air Pollution by Jermy Colls
8. Air Quality by Yael Celhal

ATM-31-T Hydrometeorology [2 Credits]

Hydrological Cycle, Factors affecting Runoff: Rainfall-Runoff Components; Hydrograph methods: Peak flow Equation; Run off variability; Urban runoff and Modeling.

Rainfall networking; Radar rainfall estimation; Rainfall over catchments areas; optimization of rainfall Observations ;Area depth Rainfall estimates; maximum probable Rain fall; Storm Displacement.

Maximum Observed Floods, Synoptic system causing floods, frequency analysis of rainfall, probability distribution, design floods.

Free Surface Evaporation: Pan Evaporation water; budget and energy budget methods; mass transfer method; combined aerodynamic and budget method.

Soil and plant evaporation Lysimetry. Soil moisture measurements; water budgets.

Books

1. Introduction to Hydrometeorology by James R. Bruise and R.H. Clark
2. Introduction to Hydrology by Viessman
3. Cold Climate Hydrometeorology by D.S. Updhyay
4. Recent advances in the modeling of hydrologic systems: Series C : Mathematical and Physical Sciences, David S. Bowles and P. Enda O' Connel
5. Modelling components of hydrologic cycle. V.P Singh (Edited)
6. Land surface hydrology, meteorology and climate; Observations and Modelling, Venkataraman Lakmi, John Albertson and J. Sheake.

ATM-23-L Chart Analysis [2 Credits]

1. Analysis of Weather Charts of some typical weather situations over India.
   a) Monsoon b) Summer c) Western Disturbance d) Tropical Cyclone.
2. Vertical Time and Space Sections
3. Analysis of Thermodynamic Diagram.
4. Computation of CAPE and CINE
5. Construction of Wind Rose.

ATM-24-L Numerical Analysis and Computer Programming [3 Credits]

FORTRAN and C Programming.

1. Computation of Correlation Coefficient, chi-squares Test, T-test.
2. Power Spectrum Analysis
3. Interpolation of data using cubic spline.

4. Numerical Integration.
5. Second and fourth order finite difference schemes for first and second derivative.
6. Harmonic Analysis
7. Solution of Differential Equations by Runge – Kutta method.
8. Computation of Divergence, Vorticity and Vertical velocity
9. Computation of Static Stability
10. Computation of Geostrophic and Gradient wind.

ATM-25-L Computations in Dynamic Meteorology and NWP [5 Credits]

1. To obtain kinematic vertical velocity by
   A. using grid point data B. using station data
2. Five point and Nine point Arakawa Jacobian Scheme.
3. To determine from geopotential field stream function using Relaxation method.
4. To determine geopotential heights from wind field-using linear balance equation.
5. To determine stream function using double Fourier transform.
6. Subjective analysis of geopotential height.
7. Objective analysis of geopotential height.
8. Solution of non-divergent barotropic vorticity equation.
9. Computation of apparent heat source and moisture sink.
10. Sensitivity studies using Energy Balance Climate Model.
11. To determine the relation between SST anomaly and Surface Pressure over Arabian Sea for Pre and Post Monsoon condition.
12. Estimation of pollution from point source.
13. Input of station data of a meteorological parameter and converting the same from Vector to RASTER using GIS software and Analyzing the same using Arc GIS.

ATM-26-P Internship Training [10 Credits]

Internship training will be for a minimum duration of 6 weeks and can be taken at University/ Research Institute/ Industry and Organizations dealing with work related to Atmospheric Sciences. (Exact duration will be as per the University calendar).

At the end of the Internship Training the student has to submit a Internship report to the University which will be assessed for 10 credits in the following manner.

5 credits for the report to be given by the guide. 5 credits for viva-voce examination.

ATM-27-P Project [40 Credits]

Project will be for a minimum duration of 24 weeks and can be taken at University/ Research Institute/ Industry and Organizations dealing with work related to Atmospheric Sciences.

Project will be spread over two Semesters (III and IV). (Exact duration will be as per the University calendar).

The project will be evaluated as follows.

At the end of the third semester student will be required to appear for a mid project assessment and give a viva on the progress made.. This will be evaluated for 10 Credits by a panel of two examiners. The guide will not be an examiner. A report on the progress made will be given by the examiners to the student with a copy to the guide.

In case the student is away on field trip and cannot appear for a Mid-Project Viva Voce exam (like he is away in Antarctica etc), he will have to submit a written report which will be evaluated by two examiners for five credits each and the sum total will be given.

If the student fails to appear for the Mid-Project viva or submit the report at the end of third semester, his term will be extended by another semester. A Mid-Project evaluation or report is mandatory before he submits the final project report.

At the end of fourth semester the student will be required to submit a Project Report to the university.

The project report will be evaluated by the external examiner for 10 credits.

The Guide will evaluate for 10 credits.

After the external examiner gives his report the student will have to give a Viva-voce examination which will be evaluated for 10 credits by two examiners.