Syllabus for B.Sc. Meteorology

Prepared by

Central Department of Hydrology and Meteorology

Tribhuvan University

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Institute of Science and Technology

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2013

Structure of four year B. Sc. Meteorology course

Introduction

There is, possibly, no subject connected with the different operations of nature that affords higher importance to the follower of natural happenings, than Meteorology. It is satisfying to do this research, which is full of interest, is at length embraced by a large part of the society.

Tribhuvan University has been offering B.Sc. level course in the field of Hydrology and Meteorology since last four decades. Primary objective of this course is to produce manpower in the field of Hydrology, Meteorology and Climate Change. This syllabus aims at fulfillment of the following objectives:

1) To meet the scientific need of skilled manpower in the field of Hydrology, Meteorology and Climate Change in the context of geographical situation and scientific development of Nepal at present

2) To provide advance knowledge to the students according to recent trends and development of the subject throughout the world

3) To enable the students to perform research in the field of specialization

Eligibility for admission

10+2 graduates with Physics, Chemistry and Mathematics

Acknowledgment

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Structure of four year B. Sc. Meteorology course

Year	Theory	FM	Practical	FM
First	Physical Meteorology MET 101 Climatology MET 102	50 50	Physical Meteorology and Climatology Practical MET 103	50
Second	Applied Meteorology MET 201 **Group A** -Urban Meteorology -Air pollution -Atmospheric Chemistry **Group B** -Agriculture Meteorology -Satellite Meteorology -Hydrometeorology	100	Applied Meteorology Practical MET 202	50
Third	Synoptic Meteorology MET 301 Fluid Dynamics MET 302 Research Methodology **Elective:** Mountain Meteorology MET 303 Micrometeorology MET 304	50 50 100 50 50	Practical (Weather analysis and forecasting) MET 305	50
Fourth	Aviation Meteorology MET 401 Dynamic Meteorology	50 50 100	Practical (Dynamical) MET 407	50

	MET 402 Climate Change MET 403 Applied Hydrology MET 404 **Computational Course:** Computational methods for Meteorology MET 405 **Interdisciplinary Course:** Monsoon Meteorology MET 406	100 50 50	Practical (Applied Hydrology) MET 408	50

First Year

Physical Meteorology

Course Title: Physical Meteorology
Course Number: MET 101 Full Marks: 50
Nature of Course: Theory Pass Mark: 35 %

Course Objectives:

This course provides basic knowledge of the quantitative treatment of the energy processes in the atmosphere. The relationship between the atmospheric variables is derived in the form of basic equations. Some of the processes going on the atmosphere are treated quantitatively.

Course content:

Meteorological Variables: Introduction to the conventional measurements of different parameters (Rain gauges, Thermometer, Anemometers, Evaporation pan, Solar radiation, Sunshine duration, Soil temperature, Dry bulb and wet bulb temperature), Automatic Weather Station, Weather Satellite, Radar, Radiosonde and Pilot Balloon. 10 hrs

The atmosphere: Physical foundation (Introduction of **thermodynamics, radiation, Newton's law), units and dimension,** composition of the atmosphere (The composition of dry air, Water vapor in the atmosphere, Carbon dioxide, Interplanetary Gas), Vertical Division of the atmosphere (Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere).10 hrs

Atmospheric Pressure: The nature and units of the atmospheric pressure, the measurement of atmospheric pressure, Mercury barometers, corrections for standard conditions, Aneroid barometers, barographs, Variation of pressure with altitude, Reduction of pressure to standard levels. 10 hrs

Equation of state: Variable of state, Derivation of Charles' Law and Boyle's Law, equation of state of an ideal gas, mixture of gases 7 hrs

Heat and Energy: specific heat capacity, internal energy, **conservation of energy, adiabatic processes, Poisson's equation,** entropy and the second law of thermodynamics, Thermodynamics of moist air (equation of state of moist air, changes of phase and latent heat, The Clausius-Clapeyron equation, adiabatic processes of saturated air. 10 hrs

Moisture variable: Brief introduction of vapor pressure, absolute humidity, mixing ratio, specific humidity, relative humidity, virtual temperature, dew point temperature, lifting condensation level (LCL), wet-bulb temperature, wet-bulb potential temperature, equivalent temperature and equivalent potential temperature. 7 hrs

Thermodynamic diagram: Principle of equal area transformation, the Emagram and the Tephigram. 7 hrs

Hydrostatic Equilibrium: Hydrostatic equation, hydrostatic of special atmosphere (the homogenous atmosphere, the isothermal atmosphere, the constant lapse rate atmosphere, the dry adiabatic atmosphere and the US standard atmosphere. 7 hrs

Hydrostatic stability and convection: Dry and moist adiabatic lapse rate, the parcel method, the slice method. 7 hrs

Text Book

- Hess, S. L., An Introduction to Theoretical Meteorology

Reference Books

- George J. Haltiner and Frank L. Martin, Dynamical and Physical Meteorology, McGraw-Hill Book Company.
- Compendium of Physical Meteorology class- IV, WMO, Geneva.
- David G. Andrews, An Introduction to Atmospheric Physics, Cambdrige University Press, 2000.

Climatology

Course Title: Climatology

Course Number: MET 102 Full Marks: 50

Nature of Course: Theory Pass Mark: 35 %

Course Objectives:

The climatology course is designed to provide basic knowledge on introductory matters of climate science. In addition, the physical causes of the climate and its variation in both space and time are provided.

Course contents:

Introduction to the climate system: Atmosphere, Ocean and land surface, atmospheric temperature, atmospheric composition, weather and climate, Definition and scope of climatology, sub-division of climatology, Factors affecting climate. 10 hrs

Precipitation: Precipitation process, Ice-crystal theory, Collision-coalescence theory, Forms of precipitation, Types of precipitation, Seasonal variation of precipitation, Diurnal variation of precipitation. 8 hrs

Heat exchanges in the atmosphere: Solar radiation, insolation, terrestrial radiation, heat exchange process, the energy budget of the **atmosphere, the effect of radiation at the earth's surface,** temperature difference between land and sea surface, albedo 12 hrs

Air Masses : Definition and Characteristics, source region, air mass modification, classification of air mass 7 hrs

Classification of climate, their type and distribution: Need and **objectives of classification, basis of classification, Kop pen's** classification, Thornthwaites classification, Tropical rainforest climate, savanna climate, tropical monsoon climate, Sahara type climate, low-latitude steppe climate, middle-latitude steppe climate, middle-latitude desert climate, Mediterranean climate, china type of climate, temperate oceanic climate, humid continental climate, hot summer climate, humid continental mild summer climate, taiga climate, Tundra climate, ice-cap climate, high land climate. 20 hrs

Climate of Nepal: East West variation, orographic variation, western disturbances, Convection in pre and post monsoon, summer monsoon. 12 hrs

Climate Change and its Impacts: Introduction, Green House Gases (GHGs), anthropogenic change of climate, Impact of climate change in Nepal. 6 hrs

Text Book

- Dennis L. Hartmann, 1994, Global Physical Climatology, International Geophysical Series, Academic Press
- Lal, D.S., Climatology, Sharda Pustak Bhawan, Allahabad, India, Revised and enlarged edition 2001

Reference Book

- Sellers., W. D., Physical climatology, University of Chicago Press.
- Conrad, V. and Pollack, L., W., Methods in Climatology, Second edition, HARVARD University Press, Massachusetts, 1962.
- Chritchfield, H. J., General Climatology, Prentice Hall of India Private Limited, New Delhi, 1975.

Physical Meteorology and Climatology Practical

Course Title: Physical Meteorology and Climatology Practical

Course Number: MET 103 Full Marks: 50

Nature of Course: Practical Pass Mark: 40 %

The student must complete following practical courses during the first year period;

Group A: Physical Meteorology

Practical No 1: Computation of lapse rate of given data (using radiosonde data), RAOB

Practical No 2: Estimation of mixing ratio, RH, LCL from tephigram

Practical No 3: Estimation of CCL from tephigram

Practical No 4: Measurement of Surface Meteorological variables: Temperature, precipitation, wind speed, wind direction, atmospheric pressure, sunshine duration, humidity, solar radiation

Practical No 5: Determination of stability of the atmosphere using various meteorological parameters

Practical No 6: Plotting of vertical height vs temperature graph from given data and interpret

Practical No 7: Calculate a weighted average of annual total rainfall of Kathmandu Valley for the period 1971 to 2000.

Practical No 8: Measure the degree of correlation between rainfall, humidity and surface air temperature.

Practical No 9: Find out the auto correlation of temperature of a given station from 1971-2010.

Practical No 10: Meteorological Station visit.

Group B: Climatology

Practical No1: Determine the principle climatic types to which each of them belongs by using koppen climatic classification method.

Practical No 2: The rain fall of station A from 1981 to 2000 is given, (a) find out the magnitude of rain fall with probability of 50% and 25% (b) what will be the probability corresponding to rainfall of 1460mm.

Practical No 3: Given below is the mean temperature of January of **station 'A' from 1981 to 2010. Calculate the moving** average (5 years running mean). Plot year Vs mean in the same graph. Comment the two graphs.

Practical No 4: Compare potential evapotranspiration (PET) estimated by the Thronthwaites method and evaporation obtain by pan and relate them with seasonal precipitation with the given data of a station.

Practical No 5: Computation and interpretation of annual average, standard deviation, and coefficient of variation (rainfall and temperature) of a given station of Nepal.

Practical No 6: Computation of moving average and interpretation of monthly climatological summary

Practical No 7: Compute and plot rainfall standard anomaly of given series for the period 1971-2010 and interpret.

Practical No 8: Compute and plot temperature standard anomaly of given series for the period 1971-2010 and interpret.

Practical No 9: Computation of water balance parameter using Thornthwaite method

Practical No 10: Computation of energy balance parameter using Thornthwaites method.

Second Year

Applied Meteorology

Course Title: Applied Meteorology

Course Number: MET 201 Full Marks: 100

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Applied Meteorology course is designed to provide the students with the basic knowledge on applications of atmospheric sciences on various fields, which includes urban meteorology, air pollution, atmospheric chemistry, satellite meteorology, hydro-meteorology and agriculture meteorology.

Course content:

***Group A (*Urban Meteorology, Air pollution and Atmospheric Chemistry)**

Urban Meteorology

Introduction: The urban surface, concept of urban atmosphere, radiation in the urban atmosphere, heat storage in urban structures. 3 hrs

Urban Processes: Convective fluxes and urban energy balance, the surface urban heat island, urban heat island genesis and control, urban wind profile, turbulence and dispersion. 5 hrs

Urban Effects: Urban effects on precipitation, humidity and dew, climate sensitive urban designing and planning. 5 hrs

Air pollution

The atmospheric boundary layer: Solar radiation, terrestrial radiation, soil temperature, local wind structure, air stability, the logarithmic profile, the Ekman spiral, turbulence, statistical methods, boundary layer scaling. 12 hrs

Pollutants and their properties: Sources and emission of air pollutants, residence time, sulphur containing compounds, aerosols and their physical, chemical and optical properties. 12 hrs

Dispersion of pollutants: Turbulent gradient transport, statistical theories of turbulent diffusion, gaussion plume model, plume rise and effective stack height. 10 hrs

Atmospheric Chemistry

Atmospheric composition: Atmospheric composition, Global cycle and lifetimes, atmospheric residence time, the global temperature record, solar variability. 6 hrs

Ozone: Atmospheric Ozone, stratospheric ozone, ozone flux from the stratosphere to the troposphere, tropospheric ozone, ozone hole. 5 hrs

Particulate matter: Stratospheric aerosol, chemical components of tropospheric aerosol, sizes of atmospheric particles, cloud condensation nuclei (CCN), sources of atmospheric particulate matter. 8 hrs

Atmospheric Chemistry and Climate change: Introduction, global carbon cycle, global CO_2 budget, feedbacks in global climate, Direct radiative impacts, indirect radiative impacts. 9 hrs

Group B (Satellite Meteorology, Hydro-meteorology and Agriculture Meteorology)

Satellite Meteorology

Introduction: Introduction to Remote Sensing, Concepts of Radar and satellite observation platform, Types of Radars and satellites, Energy sources and relation principles (E-M radiation and radiation laws), energy interactions in the atmosphere, energy interaction with earth surface features. 10 hrs

Satellite Sensors : Introduction. Quantitative information from satellites, bright bands , basic terms used in satellite meteorology and remote sensing. 5 hrs

Characteristics features of satellite imageries: Different type of satellite images viz, visible, IR , Water vapor, microwave. Image Interpretation, Cloud features associated with jet stream. 10 hrs

Hydro-meteorology

Fundamental of Hydro-meteorology: Hydrometeorology, Hydrological cycle and its components , evaporation,

condensation, precipitation, interception by the vegetation, infiltration, percolation, subsurface flow, surface runoff, recharge ground water, Hydro-meteorological hazards (definition and types) 5 hrs

Precipitation: Measurement of Rainfall (Recording, non recording, rain data logger, weather radar, totalisers), network design (optimum number of rain-gauge station, ideal location), estimation of missing data (arithmetic, normal ratio, weighted average of four station, interpolation from isohyetal maps, regression method), double mass curve, computation of average rainfall (isohyetal, Thiessen polygon, arithmetic), history and status of precipitation measurement in Nepal. 10 hrs

Snow and Glacial Hydrology: Introduction of snow and ice, Metamorphism of snow, Densification of snow, snowline, snow albedo, snow avalanche, Definition and types of glacier and Himalayan glaciers, Zones and equilibrium line in a glacier and their importance, Heat budget on snow, glacier ice and debris, Snow accumulation, ablation zone, Mass balance of snow, snow and glacier fed rivers of Nepal, Glacier lake outburst flood (GLOF). 10 hrs

Agriculture Meteorology

Introduction: Definition and scope, Plants, farm animals, artificial modifications of meteorological and hydrological regimes. 4 hrs

Photosynthesis: plant and animal physiology, seed germination and pollination 6 hrs

Radiation and Heat Balance: Radiation in crop stands, radiation minimum temperature, transmission of heat in to the soil, thermal aspects of snow cover, soil temperature, diurnal and annual variations of soil temperature. 5 hrs

Water and hydrological cycle in agriculture: water and vegetation, moisture characteristics of soil, determination of water loss from soil surfaces, combination model methods of Penman and others, special forms of precipitation, soil moisture budgets- irrigation need. 5 hrs

Weather Hazard affecting agricultural output: Hail, fire in vegetation, Drought, flood, erosion, pests, disease, storage losses, frost risk. 5 hrs

Text Books

- Seinfeld John H. and Pandis Spyros N., Atmospheric Chemistry and Physics from air pollution to climate change, A Wiley- Inter-science Publication 1997.
- David A. Lynn, Air Pollution threat and response, Addison - Wesley Publishing Company.
- WMO, Agriculture Meteorology
- Gerg, S. K., Applied Hydrology
- Satellite Meteorology & Global Climate, Volume 1, Ahamadabad, India

References:

- Boundary layer Meteorology (www.springerlink.com)
- Urban Ecosystems (www.springerlink.com)
- Lillesand M. Thomas, Kiefer W. Ralf, Remote sensing and image interpretation, third edition. JohnWiley and Sons, lnc..New York 1994.
- Shakya, B., Elements of Practical Hydrology and Meteorology.
- J. Wieringa and J. Lomas, 1996, Lecture notes in Agricultural Meteorology

Applied Meteorology Practical

Course Title: Applied Meteorology Practical

Course Number: MET 202 Full Marks: 50

Nature of Course: Practical Pass Mark: 40 %

The student must complete following practical courses during the first year period;

Practical No 1: Estimation of missing rainfall data

Practical No 2: Isoheital, Thiessen Polygon method and arithmetic average of rainfall depth

Practical No 3: Preparation of rainfall mass curve and hyetograph

Practical No 4: Double mass curve

Practical No 5: Drought analysis

Practical No 6: Optimum number of raingauge stations

Practical No 7: Relationship between snow albedo and snow ablation

Practical No 8: Energy balance and mass balance snow and glacier

Practical No 9: Basic observation rules in agro-meteorology

Practical No 10: Measurements using Agro-meteorological instruments

Practical No 11: Use of climatic data for agro-ecological zoning

Practical No 12: Draw a wind rose diagram

Practical No 13: Estimation of effective stack height using different equations

Practical No 14: Estimation of ventilation coefficient

Practical No 15: Size distribution of aerosol particles

Practical No 16: Estimation of SPM

Practical No 17: Ground level concentration by Gaussian plume model

Practical No 18: Urban air quality (Sox, NOx, HC) analysis from the given data

Practical No 19: Satellite image interpretation

Practical No 20: Delineation of urban heat island

Third year

Synoptic Meteorology

Course Title: Synoptic Meteorology

Course Number: MET 301 Full Marks: 50

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Synoptic meteorology course is designed to provide the students with depth knowledge on various aspects of weather analysis and forecasting.

Course content:

Definition and scope of synoptic meteorology: Synoptic scale, synoptic hours, surface weather map analysis 2 hr

Air mass: Introduction, Area of formation and classification, Cold and warm air masses, Continental and maritime air masses, Air mass modification 8 hr

Fronts: Introduction, properties and classification of fronts (warm, cold and stationary), Locations of front in different seasons, Atlantic ocean area, Pacific area, Front models and weather associated with it, Quasi-stationary front, Warm front, Cold front (slow and fast moving) front, Occluded front, Warm front occlusion, Cold front occlusion, Frontogenesis and frontolysis (derivation). 10 hr

Wind: Global wind, Trade wind, Geostrophic and Gradient wind, Local wind (land breeze, sea breeze**), the earth's heat energy balance,** single and three cells models. 7 hr

Synoptic climatology of extra-tropics: Introduction to the zonal index, Synoptic situation during high index period and low index period 2 hr

Extra tropical cyclone and anti-cyclone: Polar front theory (life cycle), Cyclone energetic, Cloud and precipitation associated with it, Vertical structure, Movement, Polar continental highs, Subtropical anticyclone, Highs within the cyclone, Polar out-break high, Cut-off cyclone and anticyclone 10 hr

Monsoon: Introduction- southwest monsoon and northeast monsoon, Differential heating theory, Migration of ITCZ, Monsoon vagaries: Onset of monsoon and its importance associated with it, Onset criteria,

Trough and weather associated with it, Depression and its movement, Break/active monsoon and its synoptic situation, Withdrawal of monsoon 14 hr

Northeast monsoon: Low pressure area during northeast monsoon, Depressions and tropical storms, Easterly waves 5 hr

Western disturbances (WD): Introduction and formation, Synoptic situation during the formation of WD, Movement of WD and weather associated with it. 3 hr

Tropical storms: Introduction, classification of the storm, Life cycle of the tropical storm: Formative stage, Immature stage, Mature stage and Decaying stage, Areas and frequencies of formation of tropical storm, Atlantic ocean, Pacific ocean and Indian ocean, Characteristics of tropical storm, Surface pressure: Surface Temperature distribution, Surface wind, Upper wind, Rainfall distribution, Eye, State of sea, Cloud, Motion of the tropical storm, Internal force, External force, Re-curvature and Satellite tracking, Forecasting of tropical storm, Statistical method, Persistence method, Climatological method, Numerical Weather Prediction of tropical storm 14 hr

Text Books

- Petterssen, Sverre, 1941: Introduction to Meteorology, Mc-Graw Hill Book Company Inc., New York and London
- Petterssen, Sverre, 1956: Weather analysis and forecasting. Vol I and II, Mc-Graw Hill Book Company Inc., New York.
- Herbart Riehl: Tropical Meteorology, 1954, Mc Graw Hill, New York

References

- Ramage, C. S., 1971: Monsoon Meteorology, Academic Press, NewYork
- Critchfield, H. J., 1974: General Climatology, Prentice-Hall

Fluid Dynamics

Course Title: Fluid Dynamics

Course Number: MET 302 Full Marks: 50

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Course of Fluid Dynamics is designed to provide students with depth knowledge on various aspects of fluid which are associated with different physical conditions.

Course contents:

Definitions and Properties of Fluids: Matter-its classification; Classification of fluids- liquids and gases; Types of Fluid – ideal, real, Newtonian, non-Newtonian, ideal plastic, thyxotropic fluids; Liquids and their properties-density, specific weight, specific gravity, compressibility; surface tension, capillarity, viscosity; Composition of Forces- triangle law, parallelogram law and polygon law; Dimensions, Units and Systems of measurement. 10 hrs

Viscosity- dynamic and Kinematic viscosity: Surface tension-pressure intensity inside a droplet, pressure intensity inside a hollow bubble; Thermodynamic properties-isothermal and adiabatic process; Capillarity of water 8 hrs

Fluid Pressure and its Measurement: Fluid pressure; pressure **head; Pascal's Law; Atmospheric Pressure; Gauge pressure;** Negative pressure or vacuum pressure; Barometer-aneroid and Siphon barometer; Pressure in compressible fluids-isothermal and adiabatic process. 6 hrs

Hydrostatics and Its Applications: Definition, Total pressure on an immersed surface- horizontal, vertical and inclined surfaces; Centre of pressure for vertically and inclined immersed surfaces; Pressure diagrams- (a) pressure due to one kind of liquid on (i) one side, (ii) over another, on one side and (b) pressure due to

liquids on both sides; Practical applications of hydraulics on – Sluice gate, lock gates, masonry walls and dams 14 hrs

Equilibrium of Floating Bodies: Buoyancy; Centre of buoyancy; Conditions of Equilibrium of a floating body-stable, unstable and neutral equilibrium 3 hrs

Kinematics of Fluid Flow: Introduction; Methods for describing fluid motion- Lagrangian and Eulerian methods; Lines of flow-path line, stream line, streak (or filament) line, potential lines; Types of fluid flow- (i) Laminar flow and turbulent flow, (ii) Steady and Unsteady flow, (iii) Uniform and Non-uniform flow, (iv) Rotational and Irrotational flow (v) Critical, sub-critical and super critical flow, (vi) Compressible and incompressible flow; Various types of fluid movements- (i) a pure translation (ii) pure rotation, (iii) linear deformation, (iv) angular (shearing) deformation; One, two and three dimensional fluid flow; Rate of flow or discharge 12 hrs

Continuity equation: one dimensional steady and unsteady flow, three dimensional flow; Velocity and acceleration of fluid particles- normal and convective acceleration; Stream function-physical and mathematical concept, properties of stream function, Applicability of Continuity equation; Equipotential line; Stream line. 9 hrs

Circulation: Circulation around the sides of a rectangle; Rotation and Vorticity; Equation of stream line; Flow net; Drawing of flow net- graphical and electrical analogy method 5 hrs

Dynamics of Fluid Flow: Energy possessed by a fluid in motion-potential, kinetic, pressure and total energy or head; Energy Equation- General energy equation for a steady flow; Bernoull**i's theorem and its statement; Bernoulli's theorem for liquids; Euler's equation of motion and derivation of Bernoulli's equation; Derivation of Bernoulli's equation from Euler's equation of motion for a stream tube; Euler's equation for** motion normal to streamline; Assumptions underlying **Bernoulli's equation; Limitations of Bernoulli's equation; Kinetic energy correction factor; Practical applications of Bernoulli's**

equation-Venturimeter, Orificemeter, Pitot tube, Flow nozzle; Discharge through a venturimeter; Rate of change of momentum; Head and Power; Power of a jet of water, Momentum Equation-Linear momentum equation and Impulse-Momentum Theorem; Some applications of Impulse-Momentum Theorem; Moment of momentum equation; Fluid Motion- Types of fluid motion; Radial motion (or flow); Free cylindrical vortex; Spiral forced vertex. 22hrs

Text Book:

- Jagdish Lal; Fluid Mechanics and Hydraulics; Ninth Edition, Metropolotan Book Co. Pvt. Ltd; New Delhi

References

- A text book of Hydraulics, Fluid Mechanics and Hydraulic Machines; Khurmi, R.S; S. Chand and Company Ltd; ,Ninth Edition, New Delhi
- A Textbook of Fluid Mechanics, Rajput, R.K; S. Chand and Company Ltd; ,Second Edition, New Delhi
- Hydraulics Fluid Mechanics and Fluid Machines, Ramamrutham. S; Dhanpat Rai Publishing Company (P) Ltd., New Delhi

Mountain Meteorology

Course Title: Mountain Meteorology

Course Number: MET 303 Full Marks: 50

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Mountain Meteorology course is designed to provide the students in depth knowledge on various aspects of weather and climate of mountainous region.

Course content:

Mountain Climates: Factors that determine climate (latitude, altitude, continentality, regional circulation) 4 hrs

Atmosphere: Atmospheric Scales of motions and atmospheric composition, Pressure and wind, Clouds and fogs, mountain thunderstorm 12 hrs

Mountain winds: Anabatic and Katabatic wind, Terrain-forced flows (three factors that Affect Terrain-Forced Flows, Flow over Mountains, Flow around Mountains, Flow through gaps ,channels, and passes, Blocking, cold Air Damming, and Obstruction of air masses, On the high plains: The low-Level Jet) 14 hrs

Diurnal Mountain Winds: The Daily Cycle of Slope and Along-Valley (Winds and Temperature Structure, Modification of Diurnal Mountain Winds by Variations in the surface Energy Budget, Disturbances of the daily cycle by Larger Scale Flows, The Four Components of the Mountain wind system, Diurnal Mountain Winds in basins, Diurnal Mountain winds over Plateaus, Other Local Thermally Driven Wind systems) 16 hrs

Precipitation and Orography: Lifting mechanisms (Terrain-forced mechanisms and convective mechanisms); Orographic Precipitation (Seeder-Feeder mechanism, Upslope Condensation, Orographic Convection). 7 hrs

Mountain Waves: Waves (Atmospheric Waves, Gravity Waves, Standing Waves, Mountain Waves); Features (Introduction, Cap

Clouds, The Vertically-Propagating Waves, Breaking Waves, Downslope winds, Rotors, Rotor Clouds and Trapped Lee Waves), Climatology (Location, Tropical Mountaiin Waves, Areal Extent of Mountain Waves, Time of Year, and Time of Day) 8 hrs

Hydro-meteorological Data and Forecasting: Hydro-meteorological measurements, Hydro-meteorological data processing, Concept and types of weather forecasting, Weather forecasting methods, Satellite in weather forecasting, Weather forecasting for mountaineering expedition. 14 hrs

Text Book

- C. David Whiteman, 2000: Mountain Meteorology, Fundamentals and applications, Oxford University Press

References

- Roger G. Barry, 2008: Mountain Weather and Climate, Cambridge University Press.
- J. F. Griffiths, Handbook of Agricultural Meteorology, 1994: New Work, Oxford University Press. Academic Publication.

Micrometeorology

Course Title: Micrometeorology

Course Number: MET 304 Full Marks: 50

Nature of Course: Theory Pass Mark: 35 %

Course objectives: Micro meteorology course is designed to provide the students with depth knowledge on different aspects of energy balance on the various surface of the earth.

Course content:

General Introduction: Introduction micrometeorology, definition of surface boundary layer, relation between micrometeorology and microclimatology, scope of micrometeorology. 5 hrs

Radiation process: Definition of spectrum of radiation, effect of temperature on radiation, Introduction of short wave radiation and long wave radiation, black body radiation, definition of albedo, radiation energy at the outer boundary of atmosphere, depletion of solar radiation in the atmosphere, scattering and diffusion process of radiation, Rayleigh law of scattering. 15 hrs

All wave net radiation: Calculation and measurement of long wave radiation on the earth surface, definition of emissivity, introduction of greenhouse effect, measurement of short wave radiation from the atmosphere, definition of net radiation, measurement of all wave net radiation, total heat balance on the Earth's surface, conversion of mass flux into energy flux. 15 hrs

Ground heat flux and temperature: Surface air temperature, temperature variation on the earth's surface, soil temperature, temperature gradient and rate of temperature variation, derivation of ground heat flux at land surface, conduction of heat flux into the soil layer and determination of soil conductivity, soil moisture and its measurement, surface moisture and its measurement, soil moisture saturation process, relative humidity and specific humidity. 10 hrs

Evaporation: Evaporation from the earth surface, estimation of evaporation, measurement of temperature and relative humidity, relation between relative humidity and saturation vapor pressure, daily, monthly and seasonal variation of evaporation. 10 hrs

Stability criteria of atmosphere: Stable and unstable conditions in atmosphere, wind flow near the earth's surface, viscosity and shearing stress, surface shearing stress, wind shear and drag coefficient, difference between dynamic and kinematic viscocity, turbulent layer of atmosphere, introduction of friction velocity and roughness length, vertical wind profile in the absence of buoyancy. 10 hrs

Turbulent transfer of heat fluxes from the land surface: The Monin-Obukhov Length and Richardson Number, Relation to determine Richardson Number and its application, turbulence in atmosphere, sensible and latent heat fluxes, the ratio of diffusivity, night time turbulent heat fluxes, measurement of temperature and water vapor fluctuation. 10 hrs

Text Books:

- R. E. Munn, 1966: Descriptive Micrometeorology, Academic Press.

References:

- J. F. Griffiths, Handbook of Agricultural Meteorology, 1994: New Work, Oxford University Press. Academic Publication.
- Ronald B. Stull, 1988: An Introduction to Boundary Layer Meteorology, Kluwer Academic Publication

Weather Analysis and Forecasting Practical

Course Title: Weather Analysis and Forecasting

Course Number: MET 305 Full Marks: 50

Nature of Course: Practical Pass Mark: 40 %

The student must complete following practical courses during the third year period;

Practical 1: Meteorological observatory- site selection and types using WMO practice

Practical 2: Introduction of Stevenson screen

Practical 3: Minimum maximum thermometer for temperature measurements

Practical 4: Dry bulb and wet bulb temperature (Psychrometer) for dew point determination

Practical 5: Rain Gauge for rainfall quantification

Practical 6: Sunshine recorder for diurnal hours

Practical 7: Anemometer and wind van for wind speed and direction measurements

Practical 8: Introduction of AWS

Practical 9: Surface coding and decoding

Practical 10: Surface map plotting and analysis

Practical 11: Upper air coding and decoding

Practical 12: METAR, SPECI, TA

Fourth Year

Dynamical Meteorology

Course Title: Dynamical Meteorology

Course Number: MET 401 Full Marks: 50

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Dynamical Meteorology course is designed to provide the students with the basic knowledge on conservation principals of mass, momentum and energy. This course will help student to understand the application of these principles on dynamics of atmospheric motion, which in turn leads to the climate model development.

Course content:

Introduction: Dynamic meteorology, field variables and their derivatives, total differentiation, total differentiation of a vector in a rotating system, vector operators, unit vectors, the atmospheric continuum**,** Taylor series expansion, physical dimension and unit (Frequency, force, pressure, energy, power). 8 hrs

Atmospheric coordinates: Inertial (absolute, fixed, non-rotating) and non-inertial (relative, moving, rotating) frame of references, geocentric reference frame, Cartecian and spherical coordinates, height, pressure and potential temperature as vertical coordinates, Lagrangian and Eulerian control volume, natural coordinates, generalized vertical coordinate. 8 hrs

Static atmosphere: Hydrostatic equation, hypsometric equation, geopotential height. 4 hrs

Atmospheric forces: Fundamental and apparent forces, *b*ody forces or surface forces, pressure gradient force, gravitational force, viscous force, centripetal acceleration and centrifugal force, gravity force, the coriolis force and the curvature effect

10 hrs

Conservation of momentum: Newton's first law of motion, the vectorial form of the momentum equation in rotating coordinates, the component equations in spherical coordinates, scale analysis of equations of motion. 10 hrs

Conservation of mass: Lagrangian and Eulerian derivations and scale analysis of equation of motion. 8 hrs

Conservation of energy: The first law of thermodynamics, internal and kinetic energy, thermal and mechanical energy equations, thermodynamics of dry air, potential temperature, adiabatic lapse rate, Static stability. 8 hrs

Basic equations: Basic equations in height and pressure coordinates (horizontal momentum, continuity and thermodynamic energy equations), balanced flow in natural coordinates, geostrophic flow, inertial flow, cyclostrophic flow, gradient wind approximate, thermal wind, barotropic and baroclinic atmosphere, vertical motion (kinematic and adiabatic methods), surface pressure tendency. 12 hrs

Circulation and vorticity: Circulation theorem (Kelvin's Circulation theorem), relative, absolute and planetary vorticities, vorticity in natural coordinate, shear and curvature vorticities, potential vorticity, conservation of vorticity, easterly and westerly flows over mountain barriers. 7 hrs

Text Books:

- Holton J. R., 2004, An Introduction to Dynamic eteorology, 4th edition Volume 48, International Geophysical series, Academic Press, New York.

References:

- George J. Haltiner and Frank L. Martin, Dynamical and Physical Meteorology, McGraw-Hill Book Company.
- WMO Publication, Dynamical Meteorology, Geneva, Switzerland.

Aviation Meteorology

Course Title: Aviation Meteorology

Course Number: MET 402 Full Marks: 50

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Aviation Meteorology course is designed to provide the students with the basic knowledge on application of atmospheric sciences on aviation requirements.

Course content:

Jet stream: Introduction, Types of Jet stream (westerly and easterly jet stream), Wind structure, Thermal structure, Geographical areas of formation and seasonal variation, Clear Air Turbulence (CAT) in relation to jet stream and its importance in aviation, Low level turbulence: convective currents, obstruction to wind flow, wind shear. 12 hrs

Thunderstorm: Introduction, Cell, super cells, etc, Life cycle of thunderstorm, Formative stage, Immature stage, Mature stage, Decaying stage, Hazards associated with thunderstorm 8 hrs

Norwesters: Introduction, Types of norwester (A, B, C and D type), Norwesters in association with winter disturbances and pre-monsoon depression, Mechanism of formation and its synoptic features. 6 hrs

Wind, Pressure and temperature: Wind near earth's surface and in free atmosphere, wind shear, mountain winds, drainage winds and their impacts in aviation, Atmospheric pressure **and its relationship with flight (QFE,QFF,QNH., etc.),** Heat exchange processes of atmosphere, Dew point, dry bulb and wet bulb temperatures, saturation of air and humidity. 12 hrs

Cloud and Visibility: **Cloud genera and its role in weather**, **Visibility and** factors affecting visibility, **Visual meteorological conditions (VMC) and Instrumental meteorological conditions**

(IMC), Fog (Types) **10 hrs**

Turbulence, Icing and aviation hazards: Low level and high level turbulence (CAT), t**hunderstorm and turbulence associated with it, airframe** icing **and aviation hazards.** **10 hrs**

Meteorological services and flight planning 5 hrs

Meteorological Watch Office and flight documentations 5 hrs

World Area Forecasting System: wind and temperature chart, Sigmet chart, air-met chart 7 hrs

References:

- Manual of Aviation Meteorology, Australia, Bureau of Meteorology.

Climate Change

Course Title: Climate Change

Course Number: MET403 Full Marks: 100

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Climate Change course is designed to provide the students with the basic scientific knowledge on different issues which are related to the climate change.

Course Content:

Introduction: Origin, composition and structure of the atmosphere, Definition, scope and sub-division of climate, Weather elements and climatic controls, Effects of climate on human civilization and local knowledge. 20 hrs

Atmospheric Heat: Distribution and atmospheric depletion of solar insulation, Heat budget and latitudinal heat balance, Heating and cooling of the atmosphere and temperature controls, Horizontal and vertical distribution of temperature and lapse rate, Temperature inversion and anomalous temperature, Daily cycles and seasonal and annual distributions of temperature over Nepal, Weather and climate. 20 hrs

Drivers of climate change: Basic causes of climate change, Atmospheric concentration, Green house gasses (GHGs), Sources of GHGs, Human responsibility for growth rates of GHGs, Green house effects, Enhanced greenhouse effect, Global warming, Geographic concentration of GHGs, emission sources of GHGs, Global energy balance, radiative forcing, Changes in solar activity, Volcanic eruptions, Aerosols, Stratospheric and tropospheric Ozone, Surface Albedo, Aircraft contrails, Aerosol-cloud-albedo effect, Heating and cooling effects of climate due to water, Uncertainties associated with different forcing mechanism. 30 hrs

Observed climate change: Observational records, Global temperature, sea level and snow cover in the Northern Hemisphere, Hydrological changes (water vapor and precipitation), Warming trends (IPCC), Increased averages and

extremes of climate, Frequency of frost days, cold days, cold nights, heat waves, warm days and warm nights. Climate systems within oceans and cryosphere (Sea ice, Great ice sheets of Greenland and Antarctica, glaciers, snow, frozen land and ice on lake and rivers). Interactions among different climate systems. Reconstruction of the past climate, Paleoclimate from tree rings and other proxy. 30 hrs

Attribution of observed changes: Positive radiative forcing and human activities, Past climate simulation with climate models, Climate projections, Model uncertainty, IPCC assessment reports, Realistic representation of the model, Fingerprints of human influences. 20 hrs

Projections of future changes: Climate change over the 21st century, Climate scenarios, Regional climate change, Carbon cycle, Physical and chemical characteristics of the oceans, Predicted change in polar and lower latitude regions. 15 hrs

Climate Change Impacts: Climate change impacts on water resources, bio-diversity, human health and socio-economy, Climate resilience, adaptation technique and mitigation of climate change. 15 hr

References:

- IPCC, 1996b: Climate Change 1995- Impacts, adaptations and mitigation of climate change: scientific-technical analyses. Contribution of Working Group II to the Second Assessment.
- Report of the Intergovernmental Panel on Climate Change [Watson, R.T., M.C. Zinyowera, R.H. Moss and D.J. Dokken (eds.)], Cambridge University Press, 880 pp.
- IPCC, Climate Change 2013: The Physical Science Basis. Summary for Policy Makers. Working Group I Contribution to the Intergovernmental Panel for Climate Change Fourth Assessment Report. Cambridge University Press
- W. M. O. (2003) Climate into the 21st Century, Cambridge University Press

Applied Hydrology

Course Title: Applied Hydrology

Course Number: MET 404 Full Marks: 100

Nature of Course: Theory Pass Mark: 35 %

Course objectives:

Applied hydrology course is designed to provide the students in depth knowledge on various aspects of hydrology. Students will learn about the precipitation, water loss, runoff, hydrograph, sedimentation, water quality and its applications.

Course content:

Introduction: Definition, scope of hydrology, hydrological cycle, availability of water on earth and Nepal, history of hydrology, importance and application of hydrology in engineering field.3 hrs

Catchment Characteristic : Stream pattern, drainage, slope, shape, altitude, stream length, catchment area, drainage density, relief, stream density and stream order, hypsometric curve, area length relation, river basin of Nepal. 5 hrs

Precipitation: Probability and random variable, distribution functions, selection of distribution function and estimation of parameters, frequency analysis, correlation, regression analysis, depth area duration curve, intensity duration curve, probable maximum precipitation (PMP). 7 hrs

Infiltration: Introduction, infiltration and percolation, factors affecting infiltration, measurement of infiltration (double and **single ring), infiltration equation (Horton's), infiltration indices** (Phi and w index), infiltration capacity curve, and infiltration process. 10 hrs

Evaporation: Evaporation process, factors affecting of evaporation, measurement and estimation of evaporation (evaporation pans, empirical equation, water balance method, energy balance and mass transfer methods), methods of reducing

evaporation, interception, depression storage, evapo-transpiration and its estimation , factor affecting ET, PET and AET, Estimation of PET (Penman, Thornthwaite, Blanney and Criddle methods). 5 hrs

Runoff: Sources of runoff, factors affecting runoff, basin yield, rainfall-runoff relationship, computation of runoff, time of concentration, runoff characteristic of stream, flow duration curve, surface water resources of Nepal, estimation of design flood, flood frequency analysis probable maximum flood (PMF). 5 hrs

Hydrograph: Hydrograph concept, factors affecting of hydrograph and shape of hydrograph, component of hydrograph, base flow separation, effective rainfall, theory of unit hydrograph, assumption, uses and limitation of unit hydrograph, derivation of unit hydrograph. 5 hrs

Ground water: Introduction (zoning of subsurface), occurrence of ground water, types of aquifers, aquifer parameters (porosity, specific yield, specific retention, storage coefficient, permeability, **transmissivity) ground water basin, Darcy's law its range** validity, field measurement of permeability, ground water exploration, safe yield, yield of dug well, artificial ground water recharge, springs (depression, contact, artesian, impervious rock, tubular), hydrothermal phenomena, surface investigations of ground water, ground water resources and its distribution in Nepal. 20 hrs

Limnology: Lakes/pond and its classification, dynamic processes in lake/pond, thermal stratification**,** methods of bathymetric survey**,** morphological parameters of the lake, depth-area-volume relationship. 5 hrs

Measurement of Stage: definition, non recording water level recorder (staff gauge –vertical, inclined and sectional, wire gauge, recording gauge (floating, bubble and radar), data logger, crest gauge and its importance, bench mark, flood mark, stage hydrograph, estimation of missing stage data, network design (optimum number of hydrometric stations, ideal location), stage measurement practice in Nepal, hydrological network of Nepal. 5 hrs

Measurement of Discharge: Definition, direct method- area velocity (Current meter, Floats-surface, subsurface and rod float), calculation of area and mean velocity, vertical velocity distribution, wading, cable way, bank operating and bridge under measurement method, types of current meter, calibration of current meter, sounding weights, adopted procedures for discharge measurement by using current meter, computation of discharge, angle correction, dilution method, electro-magnetic method, ultrasonic method, volumetric method, indirect method *(*slope area method), roughness coefficients, estimation of peak flow, hydraulic structures (uniform and non-uniform flow, notch, weirs (triangular, rectangular, trapezoidal etc,), flume (Parshal and Venturi) 20 hrs

Station calibration: Stage discharge relation, controls (permanent and shifting controls) extension and interpolation of rating curves (Steven's, logarithmic and regression analysis), rating table, validation of rating curves. 5 hrs

Erosion and Sedimentation: Erosion and sedimentation, types of erosion, sources of sediment, control measure of sedimentation, factors affecting sediment yield, suspended and bed sediment load measurement and analysis. 5 hrs

Water quality: Water pollution, major ions, water quality requirements for domestic, industry and irrigation, drinking water quality standard of Nepal and WHO. 5 hrs

Surveying: Definition and principle of hydrological survey, level, theodolite and total station, accuracy and error, measurement of horizontal and vertical angle, longitudinal and cross section survey of river, estimation of peak flow from hydrological survey. 20 hrs

Hydropower: History of hydropower development in Nepal, hydropower potential of Nepal, types and classification of hydropower, current demand and load forecast in Nepal 5 hrs

Municipal/rural water supply: History of pipe water supply in Nepal, Municipal/rural water supply demand, distribution system, methods of supplying water, status of municipal/rural water supply in Nepal. 10 hrs

Irrigation: History of irrigation development in Nepal, classification and types of irrigation, irrigation system, methods of irrigation. 10 hrs

Text Books

- Ven Te Chow, David R. Maidment and Larry W. Mays, Applied Hydrology, McGraw-Hill International Editions.

References

- Reddy JR Hydrology, 2010, Laxmi Publications
- Dr. B.C. Punmia, Askok K. Jain and Arun Jain, Survey Volume 1, 2005, Laxmi Publication
- Dr. B.C. Punmia, Askok K. Jain and Arun Jain, Survey Volume 2, 2005, Laxmi Publication
- H.M Raghunath, Hydrology Principles, Analysis, Design 1997, New Age International Publications
- Manual on Stream Gauging (Operational Hydrology Report No.13) Volume I Field Work, World Meteorological Organization.
- Manual on Stream Gauging (Computation of Discharge Report No.13) Volume 2 Field Work, World Meteorological Organization.
- KN Mutreja, Applied Hydrology, 1986, Tata McGraw-Hill Publication Company Limited.
- Yogacharya Kiran Shankar and Shrikrishna Shrestha, Jalbigyan, 1987, Curriculum Development Center, Tribhuvan University
- K.C.Patra, Hydrology and Water Resources Engineering, 2002, Narosa Publishing House.
- C.K. Sharma, A Treatise on Water Resources of Nepal, 1997, Sangeeta Sharma.
- M.M. Dandekar, K.N. Sharma, Water Power Engineering, 1997, Vikas Publication House Pvt. Ltd.
- John C Rodda, Facets of Hydrology II, 1985, John Wiley & Sons.

- S Subramanya, Engineering Hydrology, Tata McGraw-Hill Publication Company Limited, 2012.
- David Keith Todd, Groundwater Hydrology, Second Edition 1995, John Wiley & Sons.

Computational Methods for Meteorology

Course Title: Meteorological Statistics

Course Number: MET 405 Full Marks: 50

Nature of Course: Theory Pass Mark: 40 %

Course objectives: This course is design to provide the students with basic knowledge on statistical application for computation of different meteorological parameters.

Course content:

Introduction: Definition of statistics, usage, Statistics as applied to Meteorology, analysis of climate data, studies on climatic change, statistics in weather forecasting, in forecast verification, study of relation amongst variables, some limitations of statistics. 6 hrs

Frequency distribution: Variables continuous and discontinuous, frequency distribution, frequency functions, diagrammatic representation, histograms, frequency curves and ogives. 6 hrs

Measures of Central tendency or averages: Definition, requisites of good average, computation of arithmetic mean, median & mode, graphical determination of median and mode, merits and demerits of each, use of averages in meteorology. 8 hrs

Measures of dispersion / variation : Definition, various measures, range, quartile- mean- standard deviations, co-efficient variation, usage in meteorology especially in rainfall, introduction of skewness, kurtosis. 8 hrs

Correlation analysis: Definition, examples, scatter diagram, **Pearson's co**-efficient of correlation, merits and demerits, correlation analysis in meteorology, non-linear relation. 8 hrs

Regression analysis: Definition, regression lines of *x on y* and *y on*

x, standard error of estimate, merits and demerits, forecasting based on regression equation. **7** hrs

Multiple regression analysis: Definition, regression equation with two independent variables, extension to more variables, partial correlation co-efficients, multiple correlation co-efficient, screening regression (introduction only), and application in forecasting of met variables. 8 hrs

Probability theory and theoretical distributions: Definition of probability, additive and multiplicative laws, Binomial, Poisson and Normal distributions, their applications in meteorology. 7 hrs

Sampling : Concept of sampling, random sampling, level of significance, standard error, testing of significance of sample mean and testing of significance of difference between two sample **means (both large and small samples), Student's** *t*-distribution, testing the significance of correlation co-efficient. 8 hrs

Time series analysis: Definition of a time series, examples (meteorological), components of a time series (trend, seasonal cycliical and random variations), auto correlation co-efficient, its statistical significance, correlogram, random time series, stationary time series, markov series. 10 hrs

Text Book:

Gupta S. P., 2014: Statistical Methods, Sultan Chand and Sons.

Monsoon Meteorology

Course Title: Monsoon Meteorology

Course Number: MET 406 Full Marks: 50

Nature of Course: Theory Pass Mark: 40 %

Course objectives: This course is design to provide the students with basic knowledge of South Asian Monsoon circulation.

Course content:

Introduction of Monsoon: Definition, historical background, features of the monsoon winds, a simple theoretical work of the monsoon, the differential heating that drives monsoon circulation, monsoon index. 15 hrs

Synoptic component of the Monsoon: Role of ITCZ on monsoon circulation, dynamic and thermodynamics of the monsoon, easterly waves near equatorial monsoon trough, trans-equatorial flow, squall lines in the monsoon area, planetary scale monsoons, corresponding elements of winter and summer monsoon, easterly jet stream, different component of SW Indian monsoon 20 hrs

Precipitation and mesoscale feature of the monsoon: General features of monsoon rainfall, heat low, monsoon depressions, the monsoon inversion, on set of monsoon, withdrawal of monsoon, active and break monsoon, floods and drought trends of monsoon 15 hrs

Climatological features of the monsoon: Summary of mean climatological features, normal wind and pressure distribution, normal temperature distributions. 12 hrs

Walker circulation: El-Nino, La Nino, ENSO in relation to South Asian monsoon

Monsoon in Nepal: Background, socio-economic effect, rainfall and wind characteristics, summer and winter monsoons in Nepal, temporal and spatial domain of SW monsoon in Nepal, active and break situation during monsoon. 13 hrs

Text Books

- Das, P. K. The Monsoon, Second Edition, National Book Trust, India, 1998

References

- Ramage,C**.S. Monsoon Meteorology' Academic Press, New** York.,1971.
- Rao, Y. P. South west monsoon, Meteorological Monograph Synoptic Meteorology No. 1/1976 IMD, New Delhi 1976
- WMOP, UNESCO, Meteorological Results of the international Indian Ocean Expedition. Paris 1965.
- Riel H. Tropical Meteorology. Mc-Graw Hill Book Company Inc,New York 1954.

Dynamical Meteorology Practical

Course Title: Dynamical Meteorology Practical

Course Number: MET 407 Full Marks: 20

Nature of Course: Practical Pass Mark: 40 %

The student must complete following practical courses during the third year period;

Practical 1: Computation of pressure gradient force

Practical 2: Computation of gravitational force

Practical 3: Computation of viscous force

Practical 4: Computation of centrifugal force

Practical 5: Computation of coriolis force

Practical 6: Computation of geopotential height

Practical 7: Computation of tendencies

Practical 8: Computation of geostrophic motion

Practical 9: Computation of gradient wind speed

Practical 10: Computation of thermal wind

Practical 11: Computation of vertical velocity

Practical 12: Computation of horizontal divergence

Practical 13: Computation of vorticity

Practical 14: Computation of circulation

Applied Hydrology Practical

Course Title: Applied Hydrology Practical

Course Number: MET 408 Full Marks: 30

Nature of Course: Practical Pass Mark: 40 %

The student must complete following practical courses during the third year period;

Practical 1: Basin map delineation

Practical 2: Calculation of morphological parameter of the basin

Practical 3: Preparation of hypsometric curve and river profile

Practical 4: Frequency analysis of rainfall

Practical 5: Preparation of infiltration capacity curve

Practical 6: Calculation of phi and W index

Practical 7: **Determination of Horton's constant**

Practical 8: Estimation of evaporation loss from reservoir.

Practical 9: Measurement and estimation of evaporation from different method

Practical 10: Estimation of potential evapo-transpiration from Penman method

Practical 11: Preparation of flow duration curve

Practical 12: Frequency analysis of flood

Practical 13: Preparation of hydrograph, base flow of hydrograph and preparation of Unit hydrograph.

Practical 14: Calculation of aquifer parameters (porosity, specific yield,hydraulic conductivity permeability)

Practical 15: Estimation of draw down in open well

Practical 16: Estimation of safe yield of dug well

Practical 17: Preparation of stage hydrograph and computation of missing stage data

Practical 18: Calculation of morphological parameters of the lake/pond,

Practical 19: Preparation of area volume relationship of the lake/pond

Practical 20: Measurement and analysis of discharge data from (current meter, surface float, sub-surface float, rod float, volumetric method)

Practical 21: Measurement and analysis of discharge by dilution method and tracer method

Practical 22: Estimation of discharge by using Notch or Weirs

Practical 23: Preparation of rating curve, rating tables, rating equations and their alidation

Practical 24: Extension and Interpolation of Rating Curves **(Steven's method, Logarithmic and Regression** analysis method)

Practical 25: Measurement and analysis of suspended and bed load

Practical 26: Preparation and analysis of grain size curve of the given sediment sample and bed materials

Practical 27: Water quality analysis of given irrigation water sample.

Practical 28: Hydropower potential analysis of river and preparation of energy table.

Practical 29: Water supply analysis of Kathmandu valley**.**

Practical 30: Irrigation potential analysis of river.

Practical 31 : Surveying (instrumentation)

a. Study of the essentials of the theodolite.

b. Temporary adjustments of station.

Practical 32 : Surveying (operational measurement)

a. Measurement of magnetic bearing of a line.

b. Measurement of vertical and horizontal angles.

c. Calculation of distance by using theodolite.

d. Calculation of R.L. by using theodolite.

e. Surveying and ploting of the terrace of given surface.

f. Calculation of area by sub-division into triangles.

g. Calculation of area by using a planimeter.

h. Plot and draw contour of the given station from the given data.

Practical 33: Estimation of peak flood from hydrological survey data

Practical 34: Hydro-meteorological Field visit (3 weeks)

a. Preparation of longitudinal and cross section profile of the river.

b. Measurement of discharge of the river from different method

c. Visit of hydropower, irrigation and water supply project.