Fourth Year

Fluid Dynamics and Dynamical Meteorology

Course Title: Fluid Dynamics and Dynamical Meteorology

Course Number: MET 401 Full Marks: 100

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. 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 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

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; Bernoulli'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.

22 hrs

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

- Jagdish Lal; Fluid Mechanics and Hydraulics; Ninth Edition, Metropolotan Book Co. Pvt. Ltd; New Delhi
- Holton J. R., 2004, An Introduction to Dynamic Meteorology, 4th edition Volume 48, International Geophysical series, Academic Press, New York.

Reference Books

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

Engineering Hydrology

Course Title: Engineering Hydrology

Course Number: MET 403 Full Marks: 100

Nature of Course: Theory Pass Mark: 35

Course objectives:

Engineering 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.

2 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).

5 hrs

Flood hydrology: Sources of runoff, factors affecting runoff, basin yield, rainfall-runoff relationship, computation of runoff, time of concentration, runoff characteristic of stream, flow duration curve, river system and surface water resources of Nepal, Flow and Flood, Flood prediction by different methods, estimation of design flood, flood frequency analysis, probable maximum flood (PMF), flash flood and landslide dam outburst flood (LDOF), inundation, flood routing. 8 hrs

Ground water exploration : Safe yield, yield of dug well, artificial ground water recharge, springs (depression, contact, artesian, impervious rock, tubular), hydrothermal phenomena, aquifer properties and groundwater flow, surface investigations of ground water, well hydraulics (steady and unsteady flow into well), well loss, groundwater pollution and legislation, ground water resources and its distribution in Nepal.

5 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 practices 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, flume

10 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.

10 hrs

Hydropower: History of hydropower development in Nepal, hydropower potential of Nepal, types and classification of hydropower and their arrangements, estimation of hydropower, firm power and secondary power, 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. 5 hrs

Irrigation: History of irrigation development in Nepal, classification and types of irrigation, irrigation system, methods of irrigation, crop water requirement, potential and status of irrigation facility in Nepal 5 hrs

Flood risk management and river training: Definition and importance of FRM, FRM cycle, automatic data acquisition, telemetry and flood early warning, forecast verification, flood hazard, vulnerability and risk assessment (mapping of flood exposure, depth damage curve, vulnerability mapping, flood risk mapping), flood risk management, definition and concept of river training, classification of river training works, river training structures

5 hrs

Text Books

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

Reference Books

- C.K. Sharma, A Treatise on Water Resources of Nepal, 1997, Sangeeta Sharma.
- David Keith Todd, Groundwater Hydrology, Second Edition 1995, John Wiley & Sons.
- Dr. B.C. Punmia, Ashok 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
- John C Rodda, Facets of Hydrology II, 1985, John Wiley & Sons.
- K.C.Patra, Hydrology and Water Resources Engineering, 2002, Narosa Publishing House.
- KN Mutreja, Applied Hydrology, 1986, Tata McGraw-Hill Publication Company Limited.

- M.M. Dandekar, K.N. Sharma, Water Power Engineering, 1997, Vikas Publication House Pvt. Ltd.
- Manual on Stream Gauging (Computation of Discharge Report No.13) Volume 2 Field Work, World Meteorological Organization.
- Manual on Stream Gauging (Operational Hydrology Report No.13) Volume I Field Work, World Meteorological Organization.
- Reddy JR Hydrology, 2010, Laxmi Publications
- S Subramanya, Engineering Hydrology, Tata McGraw-Hill Publication Company Limited, 2012.
- Yogacharya Kiran Shankar and Shrikrishna Shrestha, Jalbigyan, 1987, Curriculum Development Center, Tribhuvan University

Atmospheric pollution and Climate Change

(Applied Science)

Course Title: Atmospheric pollution and Climate change

Course Number: MET 405 Full Marks: 100

Nature of Course: Theory Pass Marks: 35

Composition of the atmosphere: Atmospheric composition, global cycle and lifetimes, the global temperature records, solar variability. Introduction to greenhouse gases (GHGs).

5 hrs

The Atmosphere: The atmospheric boundary layer, local wind structure, stability criteria, plume behavior, logarithmic profile, the Ekman spiral, turbulence, boundary layer scaling.

5 hrs

Pollutant and their properties: Major source of gases (CO_2, SO_x, NO_x) and their residence time, physical chemical and optical properties of aerosol. Stratospheric aerosol, chemical component of tropospheric aerosol, size of atmospheric pollutant, CCN. 7 hrs

Dispersion of pollutants: Statistical theories of pollutant diffusion, Gaussian plume model, plume rise, effective stack height (Brigg's and Holland's equation) 5 hrs

Ozone: Tropospheric and stratospheric ozone, Chapman theory, depletion of ozone, ozone hole.

5 hrs

Climate change: Introduction, global carbon cycle, global carbo budget, feedback of global climate, direct and indirect impact of aerosol, role of IPCC in climate change.

8 hrs

Climate and human affairs, Climate and civilization, Earth Atmosphere: Temperature of Atmosphere and its control factors, Heating and cooling process of the atmosphere, Temperature inversion and anomalous temperature, Vertical distribution of temperature and lapse rate, horizontal distribution of Temperature, Seasonal distribution. Precipitation:- Types, forms, relation between precipitation and altitude.

12 hrs

Climatic controls: Sun and Solar Radiation:-Sun, solar altitude, solar input, solar radiation, disposition of solar radiation, seasonal variation in radiation, seasonal variation in day light, the length of day, Terrestrial and atmospheric radiation, The planerary radiation balance, solar and net radiation; Greenhouse gasses (GHGs), Green house effects and radiative forcing Rotation and Revolution of Earth and season General circulation of air and transfer of heat and moisture in atmosphere; Effects of Latitude, Altitude, Latitude, Altitude, Continentality, Ocean currents, Insolation, Prevailing winds, Natural vegetation and Soil in climate; Interactions between Atmosphere and Ocean.

12 hrs **Definition, History of climate change; Recent Climate Change Evidences**:- 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. 10 hrs

Extraterrestrial factors: Variation in the Earth's orbital characteristic:-Eccentricity, obliquity, wobbling**,** Solar output: Sunspots, Degree of hydrogen contain. 3 hrs

Internal Factors: Change in the composition of atmosphere, Change in the composition of greenhouse gas (specially carbon-dioxide), Volcanic Dust, Displacement of Continents, Human

Influence on Climate System:- Anthropogenic perturbation of the atmospheric composition, the enhanced greenhouse effect, Direct and Indirect effect of aerosols, land use change.

Climate Change Impacts: Climate change impacts on water resources, bio-diversity, Agriculture, human health, socio-economy, coastal area etc. 10 hrs

Climate resilience, adaptation technique and mitigation of climate change:

Climate resilience Concept of adaptation, adaptation characteristics and process, 10 hrs community based adaptation, Ecosystem based adaptation, NAPA, LAPA, Capture or sequester carbon emissions, Reduce global warming. 10 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. 5 hrs

Text Books

- Lyons T. J. Scott. W. D. Principal of air pollution Meteorology
- Seinfeld John 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 Publication Company.

Reference Books

- Microsyllabus and teaching metrerials of climate change for B.Sc. Mereorology, Prepared by Central Department of Hydrology and Meteorology T.U
- PCC, 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 2007, 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

Dynamical Meteorology Practical

Course Title: Dynamical Meteorology Practical

Course Number: MET 402 Full Marks: 50

Nature of Course: Practical Pass Mark: 20

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

Engineering Hydrology Practical

Course Title: Engineering Hydrology Practical

Course Number: MET 404 Full Marks: 50

Nature of Course: Practical Pass Mark: 20

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: Preparation of flow duration curve

Practical 5: Frequency analysis of flood

Practical 6: Preparation of stage hydrograph and computation of missing stage data

Practical 7: Calculation of discharge in completely penetrates a confined and unconfined aquifer

Practical 8: Calculation of drawdown in aquifer

Practical 9: Calculation of morphological parameters of the lake/pond,

Practical 10: Preparation of area volume relationship of the lake/pond

Practical 11: Measurement and analysis of discharge data from (current meter, surface float, sub-surface float, rod float, volumetric method)

Practical 12: Measurement and analysis of discharge by dilution method and tracer method

Practical 13: Estimation of discharge by using Notch or Weirs

Practical 14: Preparation of rating curve, rating tables, rating equations and their alidation

Practical 15: Extension and Interpolation of Rating Curves (Steven's method, Logarithmic and Regression analysis method)

Practical 16: Measurement and analysis of suspended and bed load

Practical 17: Preparation and analysis of grain size curve of the given sediment sample and bed materials

Practical 18: Water quality analysis of given irrigation water sample.

Practical 19: Hydropower potential analysis of river and preparation of energy table.

Practical 20: Water supply analysis of Kathmandu valley**.**

Practical 21: Irrigation potential analysis of river.

Practical 22: Surveying (instrumentation)

a. Study of the essentials of the theodolite.

b. Temporary adjustments of station.

Practical 23 : 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 24: Estimation of peak flood from hydrological survey data

Practical 25: Hydrological 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.

Tribhuvan University
Institute of Science and Technology
Four Years B. Sc. Meteorology Course of Study

Course Title: Project Work **Full Marks : 100**
Course No. : MET 406 **Pass Marks: 40**
Nature of Course: Research Work / Presentation **Year: IV**
Objective of the Course:
This course offers students to strengthen the knowledge in research based academic activities related with Meteorology.

Monsoon Meteorology

Course Title: ygoloroteM noosnoM

Course Number: MET 407 Full Marks: 50

Nature of Course: Theory Pass Marks: 17.5

Course contents:
Zonal average tropical circulation: Introduction, zonal velocity, mean meridional circulations, temperature field, moisture field, meridional transports by zonally symmetric circulations.
4 hrs
Zonally asymmetric features of the tropics: Introduction, gradient level winds, the moisture field in the upper troposphere, the temperature field, east west circulation in the tropics, the moisture field sea level pressure, other parameters. 3 hrs

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. 4 hrs

Synoptic component of the monsoon: Role of ITCZ on monsoon circulation, dynamic 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. The easterly jet stream different components of SW Indian monsoon. 4 hrs

Precipitation and mesoscale feature of the monsoon: General features of monsoon rainfall; 100 years 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. 4 hrs

Climatological features of monsoon: Summary of mean climatological features, normal wind and pressure distribution, normal temperature, distributions. 3 hrs

March of the seasons: Role of the Himalayan-Tibetan Massif in the monsoons during different seasons, general discussion of monsoon- equatorial Africa, Indonesia, Malaysian region, Indian Ocean, North Africa, Transition of circulation during autumn, winter, spring, early summer and summer season. 4 hrs

Walker circulation: Elnino, Lanino, ENSO 2 hrs

Monsoon in Nepal: Background, socio-economic effect, rainfall and wind characteristics, summer and winter monsoons in Nepal, Temporal and special domain of SW monsoon in Nepal, active and break situation during monsoon. 2 hrs

Text Book:

- Das P. K. the monsoon 2nd ed. National Book trust, India 1988.

References:

- Ramage, C. S., *Monsoon Meteorology* Academic Press, New york and London, 1971
- Rao, Y.P., *Southweast Monsoons*, Meteorological Monograph, Synoptic meteorology no 1/1976 IMD. 1976
- WMO, UNESCO: *Meteorological Results of the Int Indian Ocean Expedition*. Paris, 1965
- Riehl, H. *Tropical Meteorology*, Mc Graw Hill Book Com. Inc., New York 1970
- Krishnamurti, T.N. *Compendium of Meteorology Vol II Part 4 Tropical Meteorology*, WMO publication No 364, Geneva, 1979
- Lighthill and Pearce, *Monsoon Dynamics*, Cambridge University Press, London, 1980