Curriculum and Syllabus

Bachelor of Science (4-year Honors) in Meteorology

Department of Meteorology
Faculty of Earth and Environmental Sciences
University of Dhaka

B.S. (Session 2023-2024)

1 July 2024

1. Introduction to the Institution

On the first day of July 1921 the University of Dhaka opened its doors to students with Sir P.J. Hartog as the first Vice-Chancellor of the University. The University was set up in a picturesque part of the city known as Ramna on 600 acres of land. At present the University consists of 13 Faculties, 83 Departments, 12 Institutes, 20 residential halls, 3 hostels and more than 56 Research Centers. The number of students and teachers has risen to about 37018 and 1992 respectively. The University of Dhaka is dedicated to the advancement of learning, and is committed to promoting research in all fields of knowledge. As there are plans for continuous expansion of facilities to open new avenues and opportunities, the course curricula are updated and new research projects are undertaken every year. As the pioneer and the largest seat of learning in the country, the University of Dhaka has taken the task to foster the transformation processes of the individual students and the country as a whole through its educational and research facilities keeping up with demands of the day.

The Department of Meteorology was established on 17th July 2016 under the Faculty of Earth and Environmental Sciences by the syndicate of Dhaka University in accordance with Dhaka University Ordinance and Regulations 1973, to meet the growing demands for skilled graduates in the field of Meteorology. The department aims to develop a cohort of professionals who can help foster public or private sector delivery of meteorological and related services. In Bangladesh, meteorologists are needed for weather forecasting, disaster mitigation, climate change assessment and adaptation and generating user tailored weather and climate services in the vital areas of the economy such as agriculture, fisheries, water resources sector, navigation, aviation, weather insurance, power and industries sectors, climate resilient infrastructure designs and development and saving ecology and environment. Due to the impacts of climate change and disaster risks on the livelihood, it is crucial to address the above areas for sustainable development of the country and achieving the Millennium Development Goals of the nation.

2. Introduction to the Program

2.1 Title of the Program

The title of the program is Bachelor of Science (B.S.) in Meteorology. The program is being introduced on the basis of increased need of graduates in the field of Meteorology and related areas of Atmospheric Sciences.

2.2 Duration of the Program

It is a 4 years’ program with 8 semesters and it includes two semesters per year with the duration of 6 months each.

2.3 Eligibility for admission

A candidate has to fulfill the following minimum requirement to be considered eligible to get admitted in Meteorology:

Grade of H.S.C./Equivalent Examination	Mark of University Admission Test
Mathematics – A Physics – A Chemistry – A	Mathematics – 9 or Physics – 9

2.4 General objectives of the program

The objective is to produce expert meteorology graduates for full filling the increasing demands of meteorology graduates in the country. The program has been designed with basic to advance modules on Meteorology. Besides, the physics, mathematics and chemistry are included as foundation modules to prepare the background of the students for enabling them to capture the highly dynamical and heterogeneous atmosphere interfaced with land and sea and extremely inhomogeneous topography and land coverage.

2.5 Learning outcomes of the program:

Graduates will:

- Understand the physical basis and dynamical principles that govern a wide range of atmospheric phenomena and be able to express their knowledge and understanding clearly.
- Be able to describe and explain the origin and evolution of tropical and extra tropical weather systems across a range of scales.
- Know the basic physics and mathematics of application to understanding the atmosphere.
- Understand the weather and climate prediction techniques including their limitations.
- Learn to produce well-written, independently produced reports including the writing of Thesis.
- Learn to produce quality weather analysis charts and to interpret forecast products accurately and in a timely way, including verbally summarizing their details.
- Be able to participate effectively in team works.
- Understand the importance of early warning systems, how they are set up and their critical information relayed to users.
- Understand the processes important for Aviation Meteorology, produce charts and advisories for aviation.
- Know the relationship between agriculture and weather and climate; provide early warning and advisory to agriculture services for crop management.
- Know the basics of hydrology, hydrometeorology and their applications in water resources and flood modeling
- Will be able to analyze the causes of climate change and impacts, adaptation and mitigation strategy.
- They will have knowledge on the NWP modeling techniques and will be able run models for research and operational purpose.
- Will have knowledge to perform research in different areas of meteorology and applications.

3. Structure of Curriculum

Course credit: Total credit 140 (Theory+ Practical, viva and project).

Year 1: Total Credit (15 +17=32)

Semester 1 (15 credits)			Semester 2 (17 credits)		
Course Code	Course Name	Credit hour	Course Code	Course Name	Credit hour
MetTh 101	Physical Characteristics of Earth and The Atmosphere	3	MetTh 106	Physical Meteorology	3

MetTh 102	Linear Algebra	3	MetTh 107	General Circulation of Atmosphere	3
MetTh 103	Basic Physics for Atmospheric Science	3	MetTh108	Differential and Integral Calculus	3
MetLb 104	Programming Language - I	3	MetLb 109	Meteorological Instrumentation Lab + Field	3
MetLb 105	Physics Lab	3	MetLb 110	Programming Language - II	3
			MetV 111	Viva-voce	2
Total Credit		15	Total Credit		17

Year 2: Total Credit (18 +17=35)

Semester 3 (18 credits)			Semester 4 (17 credits)		
Course Code	Course Name	Credit hour	Course Code	Course Name	Credit hour
MetTh 201	Radiative Processes in Earth and Atmosphere	3	MetTh 207	Mathematical methods in Solving Meteorological Problems	3
MetTh 202	Introduction to Statistics	3	MetTh 208	Dynamic Meteorology	3
MetTh 203	Differential and Integral Equations	3	MetTh 209	GIS and Remote Sensing	3
MetTh 204	Atmospheric Chemistry	3	MetLb 210	Programming Language - IV	3
MetLb 205	Applications of Statistics in Meteorology	3	MetLb 211	GIS and Remote Sensing Lab + Field	3
MetLb 206	Programming Language – III	3	MetV 212	Viva-voce	2
Total Credit		18	Total Credit		17

Year3: Total Credit (18 +17=35)

Semester 5 (18 credits)			Semester 6 (17 credits)		
Course Code	Course Name	Credit hour	Course Code	Course Name	Credit hour
MetTh 301	Boundary Layer Meteorology	3	MetTh 307	Ocean Atmospheric Interaction	3
MetTh 302	Fluid Dynamics	3	MetTh 308	Radar and Satellite Meteorology	3
MetTh 303	Synoptic and Mesoscale Analysis	3	MetTh 309	Tropical Meteorology	3
MetLb 304	Fluid Lab	3	MetTh 310	Cloud Physics	3

MetLb 305	Plotting and Analyzing of Meteorological Fields	3	MetLb 311	Radar and Satellite Meteorology Lab+ Field	3
MetLb 306	Synoptic and Mesoscale Analysis Lab	3	MetV 312	Viva-voce	2
Total Credit		18	Total Credit		17

Year 4: Total Credit (18+20=38)

Semester 7 (18 credits)			**Semester 8** (20 credits)		
Course Code	**Course Name**	**Credit hour**	**Course Code**	**Course Name**	**Credit hour**
MetTh 401	Research Methodology	3	MetTh 407	Climatology and Global Climate	3
MetTh 402	Weather and Climate Modeling	3	MetTh 408	Air Quality and Air Pollution Meteorology	3
MetTh 403	Hydrometeorology	3	MetTh 409	Weather Analysis and Forecasting	3
MetTh 404	Agrometeorology	3	MetTh 410	Severe and Hazardous Weather and Natural Disasters	3
MetTh 405	Aviation Meteorology	3	MetP 411	Research Project+Field	6
MetLb 406	NWP Models and Data Assimilation	3	MetV 412	Viva-voce	2
Total Credit		**18**	**Total Credit**		**20**

Grand Total 4-year credit (32+35+35+38=140)

Course and Credit Distribution

Course/Credit	Total Theory	Total Practical	Total Field/Project and Viva	Total
Course	28	14	05	**47**
Credit	84	42	14	**140**

4. Assessment System

Theory courses		
Marks Distribution		
Class Assessment	Class attendance	05%
	In-course assessment	25%
Course Final Examination	Subjective	70%
Total		100%

Practical courses		
Marks Distribution		
Class Assessment	Class attendance	10%
	In-course assessment	40%
Course Final Examination	Subjective	50%
Total		100%

Lab + Field courses		
Marks Distribution		
Class attendance		10%
Class Assessment		15%
Field Work		25%
Lab Final Examination	Subjective	50%
Total		100%

Project Works	
Marks Distribution	
Written Dissertation	80%
Defence	20%
Total	100%

4.1 Marks of attendance

Attendance (%)	**Marks**
90 and above	05
85 to 89	04
80 to 84	03
75 to 79	02
60 to 74	01
Less than 60	00

4.2 In-course assessment for theory courses

(a) In-course Assessment may be done by taking class tests.

(b) The course teacher will announce the dates of in-course examinations at the beginning of the course (as per semester calendar). The in-course assessment will be of one-hour duration and the teacher concerned will be responsible to assess the students sitting in his/her course. There will be 2 tests for 3 credit course and 1 test for 2 credit course.

(c) Maximum duration of in-course test will be one class hour.

4.5. Course Final Examination (Theory and practical Courses)

(a) Student having 75% or more attendance on average (collegiate) are eligible to appear in the final examination.

(b) Student having 60-74% attendance are considered to be non-collegiate and will be eligible to sit for the final examination on payment on fine Tk. 1,000/= (One thousand).

(c) Student having attendance less than 60% will not be allowed to sit for the final examination but may ask seek readmission in the program.

(d) The duration of theoretical course final examinations will be as follows:

Credit	Duration of examination
4 credit course	4 hours
3 credit course	3 hours
2 credit course	2.5 hours

(e) Duration of practical examinations will be between 3-5 hours irrespective of credit hours.

The Class Test(s) for first In-course Assessment will be taken usually after covering 40% of the course topics and second In-course Assessment will be taken usually after covering 80% of the course topics. The Course Final Examination will be taken upon completion of the entire course. **In** Final Examination, each theory course will be evaluated by two teachers of the Department. If a single teacher teaches a course then the semester final test scripts must also be evaluated by two teachers, one of whom must be the course teacher, and another, a suitable second examiner who may be either from DU or outside DU. **In** the semester final examination if the difference of marks in any course is more than 20%, the script will be evaluated by a third examiner. The final marks obtained will be averaged of the nearest two marks, or third examiners marks if the difference between his/her marks and the two other examiner's marks are the same.

The total marks in a course will be converted into letter grade as under:

Numerical Marks	Letter Grade	Grade Point
80 above	A+	4.00
75 -79	A	3.75
70-74	A-	3.5
65 -69	B+	3.25
60-64	B	3.00
55 -59	B-	2.75
50 -54	C+	2.50
45 -49	C	2.25
40-44	D	2.00
Below 40	F	0.00

4.6. Degree Requirements

For the B.S. Honors degree, each student is required to:
i) Complete 140 credit hours without a F grade in any course
ii) Earn a minimum CGPA of 2.00: and
iii) Complete the program in maximum six consecutive academic years including the year of first admission into the program.

For appearing at each semester final examination, every student is to fill in examination entry form supplied by the Controller of Examination on payment of dues.

First Year

Department of Meteorology
University of Dhaka

1st Semester

Course Name	**Physical Characteristics of Earth and the Atmosphere**
Course Code & Number	**MetTh 101**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	The course introduces the basics of earth-atmospheric system, distribution of land and oceanic features and gradually builds up the information on atmospheric gaseous layers in the vertical and their physical structures and chemical composition.
Objectives	The objective is to provide the knowledge to the students about the basic features of land, ocean and atmosphere
Learning Outcomes	The students will learn about the earth-ocean-atmospheric system, topography, role of solar system in atmospheric circulation and physical structure and chemical composition of the atmosphere
Syllabus Content	Sun-earth system: Motion of earth relative to sun in elliptic orbit, characteristics of spin of earth around on own axis. Causes of seasonal and latitudinal variation of Insolation. An overview on earth system-land, ocean and atmospheric systems, geographical coordinates and shape of earth, distribution of land and ocean in the earth system, topographical feature of continents and bathymetry of oceans, role of solar system in the formation of earth's energy variation and formation of weather and climate. Vertical structure of the atmosphere- distribution of vertical temperature and atmospheric layers. Composition of the atmosphere – major and trace gases, particulate matters. Elements of weather, weather phenomena, climate controls. Ocean currents, location of desserts and forests.

LESSON PLAN

Lecture sessions	**Topics**	**Number of Classes**
Lecture Series 1	Earth system-land, ocean and atmospheric systems	15
Lecture Series 2	Role of solar system in the formation of earth's energy variation	24
Lecture Series 3	Vertical structure and Composition of the atmosphere	06
Total		**45**

Unit-wise learning outcome:

- Students will learn how four spheres interact with each other.
- They will also learn how energy from the sun drives the planet earth.

- They will know about the composite gases, vertical distribution of the atmosphere

Instruction strategy:
Lecture
Problem Practice in class
Live Streaming/virtual learning
Audio/Video Recording of the lectures

Recommended Text(s):
Aguado, E, and Burt, J. E 2010. Understanding Weather and Climate, 5/E, Prentice Hall, New Jersey, USA
Fundamentals of Physical Geography James F. Petersen, Dorothy Sack, Robert E. Gabler, Cengage Learning
Eric E. Small, The Earth System: An Introduction to Earth Systems Science
Aida Awad, Charles Dodd, Peter Selkin**,** Introduction to Earth Systems Science
Craig F. Bohren; Eugene E. Clothiaux, Fundamentals of Atmospheric Radiation, Wiley 2006.
Pidwirny, Michael J. Fundamentals of Physical Geography
Liou, An Introduction to Atmospheric Radiation. Elsevier Science 1981.
James Petersen, Dorothy Sack, Robert E. Gabler. Fundamentals of Physical Geography 2nd Edition.

Course Name	**Linear Algebra**
Course Code & Number	**MetTh 102**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	This course covers vectors, matrix theory and linear algebra, emphasizing topics useful in other disciplines. Linear algebra is a branch of mathematics that studies systems of linear equations and the properties of matrices.
Objectives	The objective is to use matrix techniques to represent and solve a system of simultaneous linear equations and understand the use of vectors in describing lines and planes in solid geometry.
Learning Outcomes	Students will have the concepts on matrices with different kind of matrix operations. They will be able to solve real life problems by converting them into a system of linear equations with the help of different matrix methods. They will have the knowledge to solve a system of linear equations by numerical iterative methods. They would also be able to interpret various operations of vectors.
Syllabus Content	Matrix: Matrix Algebra, Determinant of Matrix; Concept on System of linear equations, Solution of System of linear equations using Matrix. Row reduction and echelon forms, Matrix operations, including inverses, Block matrices, Linear dependence and independence, Subspaces and bases and dimensions, Determinants and their properties, Cramer's Rule. Eigenvalues and eigenvectors, Diagonalization of a matrix, Symmetric matrices and Positive definite matrices. Solution of linear equations using Gaussian eliminations and LU decomposition method. Iterative methods: Jacobi method, Gauss Seidel method, SOR method and their convergence analysis. Vectors: Geometric vectors, vectors in a coordinate plane, position vector, sum and difference of vectors, magnitude, unit vectors, graphs of the sum and difference. Dot product and Cross product: physical interpretation of the dot product(applications and extensions), orthogonal vectors, component and projection of vectors, cross product of basis vectors, right hand rule, physical interpretation of the cross product (applications and extensions) areas, scalar triple product, volume of a parallelepiped, coplanar vectors.

LESSON PLAN

Lecture sessions	**Topics**	**Number of Classes**
Lecture Series 1	Systems of linear equations	15
Lecture Series 2	Diagonalization of a matrix	15
Lecture Series 3	Vectors	15
Total		**45**

Unit-wise outcomes:

After the completion of the course, the students are expected to be able to

- Perform various matrix operations and solve system of linear equations using Cramer's rule, Gaussian elimination and LU decomposition method
- Solve system of linear equations using iterative methods: Jacobi method Gauss Seidel, SOR methods
- Perform vector operations

Instruction strategy:
Lecture
Problem Practice in class
Live Streaming/Virtual learning
Audio/Video Recording of the lectures

Recommended Text(s):
Anton. Elementary Linear Algebra, 8th edition.
Introduction to Linear Algebra, Fifth Edition (2016), Gilbert Strang
Sheldon Axler, Linear Algebra Done Right

Course Name	**Basic Physics for Atmospheric Science**
Course Code & Number	**MetTh 103**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	This is the introductory course of Physics, which gives basic foundation of Newtonian Physics. This course is concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effects of the bodies on their environment. Classical mechanics describes the motion of macroscopic objects, from projectiles to parts of machinery, and astronomical objects, such as spacecraft, planets, stars and galaxies. This course also covers the basic fluid dynamics and properties of matter.
Objectives	Specific objective is to buildup foundation of classical Newtonian mechanics to the students and provide understanding of the properties of matter. Another objective is to give the students basic idea about how do fluids flow
Learning Outcomes	Students will have very good exposure to basics of classical mechanics. They will be able to solve problems on force, momentum, energy conservation, moment of inertia, rotational kinematics. They will acquire the basic knowledge of fluid dynamics, which will help them understand the fluid motion in the atmosphere and ocean. Students will predict by the laws of classical mechanics how it will move in the future (determinism) and how it has moved in the past (reversibility).
Syllabus Content	Motion in two or three dimensions, e.g. projectile motion, circular motion. Notion of Force and Newton's laws of motion. Application of Newton's Law, Fundamental Forces, Frictional Forces, Conservation of momentum. Center of Mass and its Motion. Collision: Elastic and Inelastic collisions in one dimension. Impulse. Work and Energy. The Work-kinetic energy theorem. Conservative Forces and Potential Energy and their relation. Conservation of Energy. Rotational Kinematics, Moment of Inertia and its calculation, Radius of Gyration, Parallel-axis theorem, Perpendicular-axis theorem. Surface Tension and Viscosity. Adhesive and Cohesive Forces, Molecular origin of Surface Tension, Excess pressure due to surface tension at an interface. Capillarity, Surface Tension of a Mercury Drop. Variation of Surface Tension with Temperature. Newton's Law of Viscosity, Poiseulle's Formula, Applications. Stokes Law. Terminal Velocity for Falling Bodies. Variation of Viscosity with Temperature. Fluid Dynamics. Streamline Flow, Turbulence. Reynold's Number. Bernoulli's Equation. Applications. Equation of Continuity, Euler's Equation.

LESSON PLAN

Lecture sessions	**Topics**	**Number of Classes**
Lecture Series 1	Force and momentum	13
Lecture Series 2	Work and energy	12
Lecture Series 3	Surface tension and viscosity	20
Total		**45**

Unit-wise learning outcome:

- Students will have very good exposure to basics of classical mechanics.
- They will be able to solve problems of energy conservation, moment of inertia, and rotational kinematics.
- They will learn problems related to surface tension, viscosity, fluid flow and equations that provides clues for future prediction

Instruction strategy:
Lecture
Problem Practice in class
Practical Laboratory
Live Streaming/virtual learning
Audio/Video Recording of the lectures

Recommended Text(s):
David Halliday& Robert Resnick Physics for Students of Science & Engineering Pt 1&2 combine
David Halliday& Robert Resnick, Fundamentals of Physics
Robert Resnic, David Halliday and Keneth S. Krane: Physics, Vol-I & II
Giasuddin Ahmed: Properties of Matter-
Giasuddim Ahmed – Electricity and Magnetism
Giasuddin Ahmed, Physics Practical
Robert Resnic, David Halliday and Keneth S. Krane: Physics, Vol I
Properties of Matter, B. H. Flower
Mechanics; Symon, KR
General Properties of Matter, Newman, FH and Searle, VHL
Gases, Liquids and Solids; D. Tabor, Cambridge University Press, Cambridge
The Mechanical Properties of Matter: M. T. Sprackling.
The General Properties of Matter: F. W. Newman and V. H. L. Searle. , Edward Arrold Publishers, London.
Properties of Matter: S. Ahmed and A. K. Nath.

Course Name	Programming Language - I
Course Code & Number	MetLb 104
Course Type	Practical

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	This module provides the basics of computer systems and programming which is essential for the meteorology students.
Objectives	The objective to teach the student computer programming. But this is very basic which will help the students to learn programming.
Learning Outcomes	Students will gain some knowledge about operating systems and be able to install them. They will be capable use few programming languages.
Syllabus Content	• Fundamental of Computer Programming: Programming basics, Introduction to FORTRAN, How to write, process and run programming, Programming and Problem Solving. • Problem-solving techniques using computers: Flowcharts, Algorithms, Pseduo code. • Programing in FORTRAN: Syntax and semantics, Data Types, Constants, and Variables, Operation and Intrinsic Functions, Expressions and Assignment Statements, Numeric, Relational and Logical operations, Operator Precedence, single and mixed mode arithmetic, Fortran I/O and External files. • Control Constructs: IF Constructs, Nested and Named IF Constructs, SELECT CASE Construct, Do Loops, Named and Nested Loops, Implied do loops. • Arrays and Array Operations: Declarations, Array Constructors, Array Sections, Array operations, Allocatable Arrays. • Programming Units: Types of Programming Units, Main Program, External Procedures, Internal Procedures, Modules, Subroutines, Functions, Recursion.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Operating systems and Fortran	45
Total		**45**

Unit-wise learning outcome: After the completion of the course, the students are expected to be able to –

- Describe programming language: FORTRAN
- Explain any problem using Flowcharts, Algorithms and Pseudo code
- Define variables, constants, data and perform various loops

Instruction strategy:
Lecture
Programming in Computer Lab
Live Streaming/virtual learning
Audio/Video Recording of the lectures

Recommended Text(s):

- Stephen J Chapman, Introduction to FORTRAN 90/95.
- Programming in Fortran, Schaum's Outline Series.
- Gordon B. Davis & Thomas R. Hoffmann, FORTRAN 77: A Structured, Disciplined Style.

Course Name	**Physics Lab**
Course Code & Number	**MetLb 105**
Course Type	**Practical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	This is the introductory course to demonstrate the basic foundation of Newtonian Physics, capillarity and viscosity
Objectives	Specific objective is the demonstration of the laws of classical Newtonian mechanics, capillarity as well as viscosity of a viscous fluid to the students.
Learning Outcomes	Students will understand the basics of classical mechanics more. They will be able to determine the value of *g*, and verify Stoke's Law. They will better understand the characteristics of a viscous fluid which will eventually help them to understand motion and the terminal velocity of raindrop in the air.
Syllabus Content	1. To determine the modulus of rigidity of a wire by the method of oscillations (dynamic method). 2. To determine the spring constant and effective mass of spring and hence calculate the rigidity modulus of the material of the spring. 3. To determine the value of *g*, acceleration due to gravity, by means of a compound pendulum. 4. To determine the surface tension of water by capillary tube method. 5. To determine the co-efficient of viscosity of a liquid by its flow through a capillary tube. 6. To verify Stoke's law and hence to determine the viscosity of a liquid (glycerine).

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Mechanics	25
Lecture Series 2	Properties of matter	20
Total		**45**

Unit-wise learning outcome:

- Students will understand the basics of classical mechanics. They will be able to determine *g*.
- They will be able to better understand the laws related to elasticity, spring force, viscosity and terminal velocity of raindrops
- They will be able to determine the value of g, and verify Stoke's Law. They will better understand the characteristics of a viscous fluid which will eventually help them to understand motion and the terminal velocity of raindrop in the air.

Instruction strategy:

Lecture
Practical Laboratory
Live Streaming/virtual learning
Audio/Video Recording of the lectures

Recommended Text(s):

Giasuddin Ahmed, Physics Practical

Tyler, F; Laboratory Manual of Physics

Worsnop, BL and Flint, HT; Advanced Practical Physics

First Year

Department of Meteorology

University of Dhaka

2nd Semester

Course Name	**Physical Meteorology**
Course Code & Number	**MetTh 106**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	This subject deals with the study of optical and thermodynamic phenomena in the atmosphere, including the physics of clouds and precipitation. It usually deals with the basic of the optical and thermodynamic phenomena of the troposphere, its chemical composition, the laws of radiation and the physics of clouds and precipitation.
Objectives	It is designed to provide a foundation in atmospheric physics suitable for advanced study in atmospheric sciences and professional employment.
Learning Outcomes	Students will learn Physical principles that provide the foundation for meteorology that means Absorption, scattering, and transmission of radiation in the atmosphere, basic of cloud physics and precipitation process and some fundamental and apparent forces governing the atmosphere. Students will be able to use Atmospheric thermodynamic diagrams as tools in the forecasting of storm development.
Syllabus Content	Definition, scope, subject matter and short history of meteorology; Atmospheric constituents and physical variables of the atmosphere, equation of state for dry and moist air, humidity (mixing ratio) and relative humidity and virtual and potential temperature, dew point temperature, vertical distribution of moisture, barometric formula; General concept of the radiative processes of the atmosphere-atmospheric system: solar radiation, albedo of the earth surface, spatial variation of albedo, solar radiation absorbed by the surface, long wave radiation from the earth surface to atmosphere and that from atmosphere to earth surface, energy balance in the earth surface; Basic concept of atmospheric motion: pressure gradient forces generating atmospheric flow; modification of flow by Coriolis and Frictional forces; First law of Thermodynamics, Adiabatic processes of dry and wet atmosphere, potential temperature, lapse rate, atmospheric instability, thermodynamic charts (Skew-T log-P diagram), Estimation of Convective Potential Energy (CAPE); General concept of precipitations, cloud types, weather events and forecasting of weather.

LESSON PLAN

Lecture sessions	**Topics**	**Number of Classes**
Lecture Series 1	Radiation	15
Lecture Series 2	Thermodynamics and thermodynamic chart	15
Lecture Series 3	Forces in the atmosphere	9
Lecture Series 4	Cloud and precipitation	6
Total		**45**

Unit-wise learning outcome:

- Students will learn Physical principles that provide the foundation for meteorology that means Absorption, scattering, and transmission of radiation in the atmosphere
- Students will be able to use Atmospheric thermodynamic diagrams as tools in the forecasting of storm development
- They will also have basics of cloud physics, precipitation process and some fundamental and apparent forces governing the atmosphere

Instruction strategy:

Lecture
Atmospheric Observatory
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):

Henry G. Houghton, Physical Meteorology
Wallace and Hobbs, *Atmospheric Science*, Second Edition
Andrea V. Jackson, Handbook of Atmospheric Science by C. Nick Hewitt; Wiley 2008.
Peter Hobbs. Clouds Their Formation, Optical Properties, and Effects, Elsevier Science 2012.
Craig F. Bohren; Eugene E. Clothiaux, Fundamentals of Atmospheric Radiation, Wiley 2006.
Liou, An Introduction to Atmospheric Radiation. Elsevier Science 1981.
Maarten H. P. Ambaum, 2010: Thermal Physics of the Atmosphere (Wily). ISBN: 978-0-470-74515-1; 252pages.
Rogers and Yau: *A Short Course in Cloud Physics*, Third Edition
Fleagle and Businger, *An Introduction to Atmospheric Physics*, Second Edition
Robert Houze, Cloud Dynamics (Chapter-3)
Robert A. Houze Jr. Cloud Dynamics (ISSN Book 104) 2nd Edition, Kindle Edition
Horace Robert Byers, General Meteorology 4th Edition

Course Name	**General Circulation of Atmosphere**
Course Code & Number	**MetTh 107**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	The circulation of wind in the atmosphere is driven by the rotation of the earth and the incoming energy from the sun. It is very important to study the general circulation incorporated in the atmospheric motion.
Objectives	The objective is to let students learn about the wind circulation in each hemisphere which help transport energy and heat from the equator to the poles.
Learning Outcomes	Students will learn about the circulation pattern involved in three cells of each hemisphere. They will get to know about the large-scale transport of heat and moisture by means of which thermal energy redistribute over the earth.
Syllabus Content	Global radiation-seasonal distribution of annual and seasonal radiation fields – solar and terrestrial radiation, Outgoing long wave radiation and radiation balance. Large scale fluxes - Large-scale annual and seasonal fluxes of heat and moisture, and transport mechanisms. General circulation of the atmosphere over the globe - Pressure and wind belts, Distribution of pressure and temperature over the surface of the earth, Equatorial trough and Inter tropical convergence zone (ITCZ), subtropical high. Large Scale Circulation-Large-scale mean circulation features including the Hadley and Walker Circulations, Understanding of north-south vertical circulation- Hadley, Ferrel and Polar cells. Climate Indices-Climate variability indices including teleconnections; ENSO, IOD, NAO, MJO, PDO, the Quasi- Biennial Oscillation (QBO).

LESSON PLAN

Lecture sessions	**Topics**	**Number of Classes**
Lecture Series 1	Global radiation and large-scale fluxes	08
Lecture Series 2	General circulation of the atmosphere over the globe	07
Lecture Series 3	Large Scale Circulation	15
Lecture Series 4	Climate Indices	15
Total		**45**

Unit-wise learning outcome:
On completion of this unit students will be able to:
Global radiation and large-scale fluxes:
Heat and energy balance and their variation of daily, annual and seasonal time scale.
General circulation of the atmosphere over the globe:
Distribution of pressure and temperature over the surface of the earth and related parameters which govern the weather
Large Scale Circulation:

Understand the causes and mechanism of north-south and east-west large-scale circulation system of the atmosphere which helps to transport heat, energy and moisture.
Climate Indices:
Understand the causes and mechanism of various Teleconnections like ENSO, IOD, NAO, MJO, QBO etc. and their impact on regional as well as global weather.

Instruction strategy:
Lecture
Atmospheric Observatory
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
James, Introduction to circulating atmospheres, Cambridge University Press.
Hoskins &James, Fluid dynamics of the mid-latitude atmosphere, Wiley.
E. Palmén and C. W. Newton, Circulation Systems. Their Structural and Physical Interpretation. Academic Press, New York.
OchananKushnir (2000). The Climate System: General Circulation and Climate Zones.
Satoh, Masaki. Atmospheric Circulation Dynamics and General Circulation Models, Springer.
David Randall. An Introduction to the Global Circulation of the Atmosphere, Princeton University Press.
Global Atmospheric Circulations, by R. Grotjahn, Oxford Univ. Press.
N. James. Introduction to Circulating Atmospheres (Cambridge Atmospheric and Space Science Series).
Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale Circulation Hardcover– 6 Nov 2006, by Geoffrey K. Vall.

Course Name	Differential and Integral Calculus
Course Code & Number	MetTh 108
Course Type	Theoretical

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	This course provides the foundation in differential and integral calculus to the students. In mathematics, an integral assigns numbers to functions in a way that can describe displacement, area, volume, and other concepts that arise by combining infinitesimal data. Integration and differentiation are the two main operations of calculus and are inverse operation to each other. Since Meteorology is a highly mathematical subject, this course is very important.
Objectives	Specific Objective is to provide the basics of differential and integral calculus to the students and help them to use definite and indefinite integral properly.
Learning Outcomes	The basic idea on differentiation and integration will be developed. Students will use numerical methods of integration in solving differential equations and will compare with exact solution. They will learn to find derivative of various functions and different theorems relating to differentiation with their real-life applications. They will get knowledge on numerical differentiation.
Syllabus Content	Definition of derivative. One-sided derivatives. Rules of differentiation. Successive differentiation and Leibnitz theorem. Role's Theorem, Lagrange's and Cauchy's mean value theorems. Power series expansion: Taylor's theorem with general form of the remainder; Lagrange's and Cauchy's forms of the remainder. Taylor's series. McLaurin series. Indeterminate forms, L'Hospital's rules and Partial differentiation. Topics in vector calculus: Vector Fields, Gradient, Divergence, curl and their physical meanings, Line Integrals, Green's Theorem, Surface Integrals, The Divergence Theorem, Stokes' Theorem, Applications of Surface Integrals. Numerical methods of differentiation. Concept on integration; Indefinite integral: Integration of sine, cosine, exponential, logarithmic, hyperbolic functions, Integration by substitution, Integration by parts and partial fractions, computing definite integrals: Areas, volumes, Averages; Double Integrals in Polar Coordinates, Triple Integrals in Cylindrical and Spherical Coordinates, Improper integrals of different kinds. Gamma and Beta functions. Numerical methods of integration.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Indefinite and Definite integral	15
Lecture Series 2	Integrate by parts	15
Lecture Series 3	Numerical methods of integration	15
Total		**45**

Unit-wise learning outcome:

After the completion of the course, the students are expected to be able to

- Explain basic concept of differentiation and integration
- Perform differentiation and integration of different functions
- Evaluate line integrals, surface integrals, area and volume under curves

Instruction strategy:
Lecture
Problem Practice in class
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
Howard Anton, IrlBivens and Stephen Devis, Calculus, John Wiley and Sons.
M. R. Spiegel. Calculus and Analysis, Schaums's outline series.
H. Anton et al, Calculus with Analytic Geometry.
E.W. Swokowski, Calculus with Analytic Geometry.
Michael Sulivan, Pre-Calculus
Deborah Hughes-Hallett, Applied Calculus.
Stefan Waner and Steven Costenoble, Applied Calculus
G. Strang, Calculus

Course Name	**Meteorological Instrumentation Lab + Field**
Course Code & Number	**MetLb 109**
Course Type	**Practical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	The course is highly important for the students for learning the various atmospheric observing systems and instruments for measuring the atmospheric parameters on regular basis. The students will study the equipment and the data collected by the equipment. Thus, they will have the primary acquaintance with the observing systems and meteorological data and their characteristics.
Objectives	The purpose of this course is to provide the acquaintance of the meteorological observing systems, their functionality and the nature of the atmospherics parameters to the students.
Learning Outcomes	The students will be able to learn about the observing instrument and meteorological parameters and can keep record and will be able of handling and processing of surface and upper air meteorological data. They will get acquainted with the meteorological instruments in the laboratory and in the Meteorological Observatory. They will learn the general principles of observations: representativeness of observations, Metadata of Observations and general requirement of meteorological observatory.
Syllabus Content	**Surface Observation:** 1. Measurements of air temperature, dew point temperature, air pressure and relative humidity and then derive the equivalent temperature, mixing ratio, vapor pressure. 2. Data of pressure, temperature, humidity and wind (magnitude and direction) from AWS are used to investigate the diurnal variability of these parameters. 3. Measure the soil temperature at different depth for different time of the day and estimate the coefficient of conductivity of heat in the soil. 4. Measure the incident and reflected solar radiation using Pyranometer and calculate the albedo of bare soil, vegetated area (crops), sandy soil and wet soil. 5. Measure the incoming and outgoing long-wave radiation and estimate the radiance. temperature of the surface during 7:00 to 10:00 am at 10 minutes interval. 6. Monitor radiation balance and increase of temperature from 7.00 am to 10.00 am for selected surfaces. 7. Tabulation and analysis of Aviation Met Instrument including transmissometer and application, agrometeorological instruments. **Upper Air Observations:** **1.** Study the principles of upper air observations using pilot balloons and radiosonde **2.** Measuring atmospheric parameters (pressure, temperature, humidity, winds, along the vertical up to stratosphere using pilot balloons and radiosonde instruments. 3. Assess the parameters for standard atmospheric levels.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Surface observing systems	15
Lecture Series 2	Upper air observing system	15
Lecture Series 3	Remote sensing or Satellite and Radar observations	15
Total		**45**

Unit-wise learning outcome:

- Students will learn about the meteorological observing systems and data handing and archiving for surface observations
- Students will learn the same for the upper air observations

Instruction strategy:

Lecture
Atmospheric Observatory
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):

Shaw, Sir Napier. Manual of Meteorology, Vol. I. Cambridge University Pr, Cambridge, 1942.Google Scholar.
Harrison. Meteorological measurements & instrumentation, Wiley.
Fred V. Brock; Scott J. Richardson, Meteorological Measurement Systems Oxford University Press 2001.
Dwayne Heard. Analytical Techniques for Atmospheric Measurement Wiley 2008.
Giles Harrison, Meteorological Measurements and Instrumentation (Wiley) ISBN: 978-1-118-74580-9; 280 pages, November 2014, Wiley-Blackwell.
Fred V. Brock; Scott J. Richardson, Meteorological Measurement Systems, Oxford University Press 2001.

Course Name	**Programming Language - II**
Course Code & Number	**MetLb 110**
Course Type	**Practical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	This module provides the advanced knowledge of computer systems and programming which is essential for the meteorology students. For meteorologists it is a must to have a clear idea on programming languages and operating systems.
Objectives	The objective is to teach the student computer programming and help them to perform numerical operation using FORTRAN programming software.
Learning Outcomes	Students will be able to solve problems numerically using FORTRAN programming language.
Syllabus Content	• Matrix: Matrix Addition, Subtraction, Multiplication; Transpose of Matrix, Symmetric and Skew Symmetric Matrix; Matrix Algebra, Determinant of Matrix; Solution of System of linear equations using Matrix (Row reduction and echelon forms); Solution of linear equations (Gaussian eliminations, LU decomposition method); Iterative methods (Jacobi method, Gauss Seidel method, SOR method) • Vectors: Sum and Difference of vectors, Magnitude, Unit vectors, Dot product and Cross product, Component and Projection of vectors, Areas, Scalar triple product, Volume of a parallelepiped, Coplanar vectors. • Root finding problem: Bisection Method, Newton Raphson Method, Secant Method. • Differentiation and Integration: Numerical methods of Differentiation (forward and backward) and Integration (Trapezoidal Rule, Simpson's 1/3 & 3/8 Rule, Weddle's Rule). • Problem solving in concurrent courses using FORTRAN programming.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	FORTRAN operating system	45
Total		**45**

Unit-wise learning outcome: After the completion of the course, the students are expected to be able to –

- Perform different Matrix and Vector operations using FORTRAN.
- Evaluate numerical differentiation and integration using FORTRAN.

Instruction strategy:
Lecture
Programming in Computer Lab
Live Streaming/virtual learning
Audio/Video Recording of the lectures

Recommended Text(s):

- R.L. Burden and J.D. Faires, Numerical Analysis.
- H. Anton, and C.Rorres, Linear Algebra with Applications.
- Stephen J Chapman, Introduction to FORTRAN 90/95.
- Programming in Fortran, Schaum's Outline Series.

Course Name	**Viva-voce**
Course Code & Number	**MetV 111**
Course Type	

Course Information

Course Credit and Marks	**02 (Two); Full Marks 100**

All students will have a viva examination on Project work: They will prepare a power point presentation and present it before a board of experts.

Second Year

Department of Meteorology

University of Dhaka

3rd Semester

Course Name	Radiative Processes in Earth and Atmosphere
Course Code & Number	**MetTh 201**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	This course is focused on fundamental understanding of radiation processes such as absorption and scattering on the molecules, aerosols, and clouds. The main part of these lectures is devoting on the radiative transfer in atmosphere and global radiation balance.
Objectives	To know about heat transfer processes originating from the sun or the Earths.
Learning Outcomes	Students will understand radiative equilibrium, radiative-convective equilibrium, and radiative forcing discussed as an aspect of climate change.
Syllabus Content	Absorption, emission and scattering of radiation by the atmosphere. Depletion of solar radiation (direct/diffused) under cloudless and cloudy conditions, mean depletion, interaction with the earth's surface and oceans. Radiative transfer equation for the solar radiation and emitted radiation from earth and atmospheric system, Heat balance of the earth-atmosphere system and the role of carbon-dioxide, water vapor, and ozone on radiation quality and quantity. Radiation charts. Interaction of the solar radiation in the atmosphere, attenuation of solar radiation- molecular and aerosol scattering, absorption, transmission, interaction with clouds and surface, radiative transfer equation, down-welling and upwelling radiation, radiative balance and heat equation. Radiation measurement techniques.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Solar and terrestrial radiation	15
Lecture Series 2	Interaction of Radiation with the Atmosphere and surface	15
Lecture Series 3	Radiative balance in the earth Atmospheric system	15
Total		**45**

Unit-wise learning outcome:

- Solar and terrestrial radiation
- Interaction of Radiation with the Atmosphere and surface
- Radiative balance in the earth Atmospheric system

Instruction strategy:

Lecture

Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
Ambaum, Thermal physics of the atmosphere, Wiley.
R. M. Goody; Y. L. Yung, Atmospheric Radiation, Oxford University Press 1995.
Craig F. Bohren; Eugene E. Clothiaux, Fundamentals of Atmospheric Radiation, Wiley 2006.
Liou, An Introduction to Atmospheric Radiation. Elsevier Science 1981.

Course Name	**Introduction to Statistics**
Course Code & Number	**MetTh 202**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	Statistical methods have been used in meteorological research. Numerical weather prediction was not the only forecasting technique to face opposition in the 1950s. Progress in meteorology leans heavily on data and observations; consequently, statistical techniques have been widely applied to a variety of meteorological problems.
Objectives	To advocate the use of statistics in weather prediction, weather research and climatological analysis.
Learning Outcomes	Students will learn introductory statistics and learn how to compute the different statistical parameters for application in climatology, weather prediction. Data management, analysis and applications.
Syllabus Content	Introduction of Statistics, Application of Statistics in Meteorology. Population, Sample, Parameter, Statistic, Variable. Frequency Distribution construction, Graphical Representation: Line graph, Bar diagram, Histogram, Stem and leaf plot. Measures of Central tendency: Mean, Median, Mode, Application of Measures of Central Tendency in Meteorology, Measures of Dispersion: Different absolute and relative measures. Skewness, Kurtosis, Moments, Usage in Meteorology. Correlation Analysis: Scatter diagram, Pearson's Coefficient of Correlation, Regression Analysis, Estimation of parameter estimation and interpretation of output analysis. Non-linear relation and non-linear regression.Probability: Introduction, classical probability, frequency approach, subjective probability, conditional probability, Bayes' theorem. Usage in Meteorology. Probability Distribution: Probability distribution (Binomial distribution, Poisson distribution, Exponential Distribution, Gamma distribution, Beta distribution). **Bayesian distribution** Usage in Meteorology, Sampling: Introduction, SRS, Stratified Random Sampling and Cluster Sampling.

LESSON PLAN

Lecture sessions	**Topics**	**Number of Classes**
Lecture Series 1	Statistical moments	15
Lecture Series 2	Statistical probability distribution	08
Lecture Series 3	Correlations and regression analysis	15
Lecture Series 4	Data Processing and management	07
Total		**45**

The students will learn the statistical applications of the following in Meteorology and climate:

- Statistical moments
- Statistical probability distribution

- Correlations and regression analysis
- Data Processing and management

Instruction strategy:
Lecture
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
Epstein, e. S. (ed) (1985) statistical inference and prediction in climatology.
Time series analysis in meteorology & climate.Duchon& hales, wiley.
Daniel s. Wilks. Statistical methods in the atmospheric sciences.
Epstein, e. S. (ed) (1985). Statistical inference and prediction in climatology.
Claude duchon; robert hale. Time series analysis in meteorology and climatology, an introduction.

Course Name	Differential and Integral Equations
Course Code & Number	MetTh 203
Course Type	Theoretical

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	A differential equation is a mathematical equation that relates some function with its derivatives. In applications, the functions usually represent physical quantities, the derivatives represent their rates of change, and the differential equation defines a relationship between the two. Since Meteorology is a high mathematical subject, this course is very important.
Objectives	The objective is to help students to develop essential methods for obtaining numerical solutions and exploring the use of differential equations as models in various applications and the use of series methods to solve problems with variable coefficients and the methods of solving initial value problems.
Learning Outcomes	Students will apply their knowledge to the functions which usually represent physical quantities, the derivatives representing their rates of change, and the equation defines a relationship between the two. They will Model a simple physical system to obtain a first order differential equation. They will Test the plausibility of a solution to a differential equation (DE) which models a physical situation by using reality-check methods such as physical reasoning, looking at the graph of the solution, testing extreme cases, and checking units.
Syllabus Content	Types of Differential equation (DE): Ordinary Differential Equation (ODE) and Partial Differential Equation (PDE), Linear and nonlinear ODE, Order of differential Equation, Second order Partial Differential Equations, Solution of First-Order Differential Equations: Separable, Homogenous, Linear, Exact, Solutions by substitutions,, Solution of Higher-Order Differential Equations: Undetermined coefficients, Variation of parameters, Inverse operator method, Series solution, Solution of Ordinary and partial differential Equations using numerical technique.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Ordinary Differential Equation	08
Lecture Series 2	Partial Differential Equation	15
Lecture Series 3	Higher-Order Differential Equations	15
Lecture Series 4	Solve the Differential Equations using Numerical Techniques	07
Total		**45**

Unit-wise learning outcome: After the completion of the course, the students are expected to be able to -

- Identify ODE & PDE with its order and linearity
- Solve first order ODE using different methods

- Solve higher order ODE using different methods
- Find solution of ODE & PDE using numerical techniques

Instruction strategy:
Lecture
Problem Practice in class
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
Howard Anton, IrlBivens and Stephen Devis, Calculus, John Wiley and Sons.
M. R. Spiegel. Calculus and Analysis, Schaums's outline series.
H. Anton et al, Calculus with Analytic Geometry.
E.W. Swokowski, Calculus with Analytic Geometry.
Michael Sulivan, Pre-Calculus
Deborah Hughes-Hallett, Applied Calculus.
Stefan Waner and Steven Costenoble, Applied Calculus
G. Strang, Calculus

Course Name	**Atmospheric Chemistry**
Course Code & Number	**MetTh 204**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	This module provides the Chemistry of Atmosphere with specific attention to study the atmospheric and environmental chemistry, which is very important

	for meteorologists.
Objectives	To provide understanding of chemistry related to the composition of the atmosphere, radiative forcing due to GHG emission causing climate change.
Learning Outcomes	Students will learn air pollution, atmospheric chemistry and GHGs responsible for global warming. They will also learn influences of chemical reactions and Acid and basic properties.
Syllabus Content	Atmospheric Chemistry Overview – physical properties and structure of the troposphere and the stratosphere, temperature profile, concentration profiles Atmospheric Chemistry of the Troposphere – tropospheric chemical cycles, hydroxyl and chlorine radical, chemical cleansing, oxidation, hydrocarbons in the troposphere, sources and sinks Atmospheric Chemistry of the Stratosphere – stratospheric ozone cycle, depletion, NOx, halogencycles, polar stratospheric cloud chemistry Urban Smog - VOC/NOx/COx/SOx/SF6– Historical account of air pollution, progress and problems in experiments and modeling, assessing human impact on the atmosphere The Global Carbon Cycle; Biogeochemical Cycles of Methane and Nitrous Oxide, ABC Pollution: Air Quality, Acid Rain, and Aerosols Aerosols and Heterogeneous Reactions: Aerosol size distribution and composition; Aerosol and the formation of clouds; The optical properties of aerosols and clouds; Reactions of gases with particles; Impact of aerosols on weather, climate and human health; effect of aerosol on climate change The Greenhouse Effect: Radiative Transfer; Cloud and Water Vapor Feedbacks Chemistry of Global Climate Change – Historical account of greenhouse gas and aerosol concentrations, carbon dioxide, ozone and altitude, aerosol uncertainties, sulfur cycle Climates of the Past

LESSON PLAN

Lecture sessions	**Topics**	**Number of Classes**
Lecture Series 1	Atmospheric Composition and vertical structure	06
Lecture Series 2	Atmospheric chemistry of troposphere and Stratosphere	15
Lecture Series 3	Atmospheric aerosol, GHG emission and Climate Change	24
Total		**45**

Unit-wise learning outcome:

Students will know the following about the atmospheric Chemistry:

- Atmospheric Composition and vertical structure
- Atmospheric chemistry of troposphere and Stratosphere
- Atmospheric aerosol, GHG emission and Climate Change

Instruction strategy:

Lecture
Practical Laboratory
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):

Visconti, Guido: Fundamentals of Physics and Chemistry of the Atmosphere, Springer

Peter V. Hobbs, University of Washington, Basic Physical Chemistry for the Atmospheric Sciences, 2nd Edition
Chemistry of the Upper and Lower Atmosphere, B. J. Finlayson-Pitts, J. N. Pitts, Jr., Academic Press, 2001
Global Warming: The Complete Briefing 5th Editionby John Houghton
Green Chemistry: An Inclusive Approach, edited by BélaTörök and Timothy Dransfield

Course Name	**Applications of Statistics in Meteorology**
Course Code & Number	**MetLb 205**
Course Type	**Practical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	Statistical methods have been used in meteorological research since a long time. Numerical weather prediction was not the only forecasting technique to

	face opposition in the 1950s. Progress in meteorology leans heavily on data and observations; consequently, statistical techniques have been widely applied to a variety of meteorological problems.
Objectives	To advocate the use of statistics in weather prediction as meteorologists.
Learning Outcomes	Students will be able to perform spatial and temporal analysis and find out the climatology**.** They will be able to estimate the correlation between different atmospheric parameters.
Syllabus Content	Time Series Analysis: ARIMA model, SARIMA model. Output analysis and interpretation. Spectral Analysis: Use of Spectral analysis for weather and climate study through R programming. Wavelet analysis and application. Data Processing and Management: Introduction, combining two or more files, collapsing data, generating variables, Value labels, recoding variables, sorting data, besides these the functions which are helpful in the discipline of Meteorology. Factor analysis, PCA, CCA, Cluster analysis. Data Science: Introduction, Relationship between data science and statistics. How data science enhances the weather forecasting. Techniques of data science: Linear regression, ANN model. Language of data science: Python and R.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Statistical moments and distribution	15
Lecture Series 2	Time series analysis	15
Lecture Series 3	Correlations and regression analysis	15
Total		**45**

Unit-wise learning outcome:

The students will learn the following aspects of statistics as applied for meteorology

- Statistical moments and distribution
- Time series analysis
- Correlations and regression analysis

Instruction strategy:

Lecture

Live Streaming through website

Audio/Video Recording of the lectures

Recommended Text(s):

EPSTEIN, E. S. (ED) (1985) STATISTICAL INFERENCE AND PREDICTION IN CLIMATOLOGY.

TIME SERIES ANALYSIS IN METEOROLOGY & CLIMATE.DUCHON& HALES, WILEY.

DANIEL S. WILKS. STATISTICAL METHODS IN THE ATMOSPHERIC SCIENCES.

EPSTEIN, E. S. (ED) (1985). STATISTICAL INFERENCE AND PREDICTION IN CLIMATOLOGY.

CLAUDE DUCHON; ROBERT HALE.TIME SERIES ANALYSIS IN METEOROLOGY AND CLIMATOLOGY, AN INTRODUCTION.

Course Name	**Programming Language – III**
Course Code & Number	**MetLb 206**
Course Type	**Practical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	This programming course is designed to teach students the basics & advanced level of program design, coding and testing. The modern programming using MATLAB will be introduced in solving meteorological problems
Objectives	The objective is to teach the student computer programming and help them to perform numerical operation using MATLAB programming language.
Learning Outcomes	Students will be able to solve problems numerically using MATLAB programming language.
Syllabus Content	• Introduction to MATLAB: How to write, process and run MATLAB programming. • Matrix: Matrix Algebra, Determinants and their properties, Solution of System of linear equations, Inverse of Matrix, Iterative methods. • Vectors, Root finding problem, Numerical differentiation and integration. • Ordinary differential equation: Solving first order and higher ODE using different methods. • Problem solving in concurrent courses using MATLAB programming.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	MATLAB operating system	45
Total		**45**

Unit-wise learning outcome: After the completion of the course, the students are expected to be able to –

- Perform different Matrix and Vector operations using MATLAB.
- Evaluate ODE, differentiation and integration numerically using MATLAB.

Instruction strategy:

Lecture
Programming in Computer Lab
Live Streaming/virtual learning
Audio/Video Recording of the lectures

Recommended Text(s):

- R.L. Burden and J.D. Faires, Numerical Analysis.
- H. Anton, and C.Rorres, Linear Algebra with Applications.
- David Houcque, Introduction to MATLAB for Engineering Students.

Second Year

Department of Meteorology
University of Dhaka
4th Semester

Course Name	Mathematical methods in Solving Meteorological Problems
Course Code & Number	MetTh 207
Course Type	Theoretical

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	Quantitative problem-solving is a challenging aspect of any physical science course. Application of these concepts in the study of meteorological problems are provided.
Objectives	To teach students various mathematical techniques so that they can use those techniques to solve complex meteorological problems easily.
Learning Outcomes	It would be very much beneficial for the student to incorporate mathematical problem-based learning in weather forecasting.
Syllabus Content	Fundamentals of Fourier series, Fourier Transform, Laplace Transform, Henkel and Hilbert Transform, Wavelet Transform, Greens Function with application to meteorology and climatology. Solution of partial differential equations and their physical interpretation in meteorological problems. Laplace equations, heat and diffusion equation in atmospheric dynamics problem.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Fourier series	24
Lecture Series 2	Simultaneous linear equations	13
Lecture Series 3	Laplace equations, heat and diffusion equation in atmospheric dynamics problem	08
Total		**45**

Unit-wise learning outcome: The students will learn the following:

- Fundamentals of Fourier series, Fourier Transform, Laplace Transform, Henkel and Hilbert Transform, Wavelet Transform, Greens Function with application to meteorology and climatology.
- Solution of partial differential equations and their physical interpretation in meteorological problems.
- Laplace equations, heat and diffusion equation in atmospheric dynamics problem.

Instruction strategy:
Lecture
Problem Practice in class
Computer Lab
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
Thompson, Philip D. Numerical Weather Analysis and Prediction. Macmillan, New York, 1961.Google Scholar.
Richardson, Lewis F. Weather Prediction by Numerical Process. Cambridge University Pr, Cambridge, 1922.
Ducan Thompson, Philip D. A history of numerical weather prediction in the United States. In History of Meteorology in the United States: 1776–1976. American Meteorology Society, 1978.
Teach Yourself C by Herbert Schildt

Course Name	Dynamic Meteorology
Course Code & Number	MetTh 208
Course Type	Theoretical

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	It is the branch of meteorology dealing with the study of atmospheric motion and its causal relation to various forces. It deals primarily with the atmospheric processes based on the fundamental equations of dynamic meteorology. It forms the primary scientific basis for weather and climate prediction, and thus plays a primary role in the atmospheric sciences.
Objectives	The main task of dynamic meteorology is weather forecasting by numerical simulation. This course aims at providing the in-depth knowledge of dynamic meteorology.
Learning Outcomes	Students will have a study of atmospheric motions as solutions of the fundamental equations of hydrodynamics or other systems of equations appropriate to special situations, as in the theory of turbulence.
Syllabus Content	**Fundamental forces in the atmosphere-**Pressure gradient, gravity force, frictional forces; apparent forces affecting atmospheric motions. Equation of motion in inertial and rotating coordinate systems. Relative equation of motion and its components in different coordinate systems (Cartesian, Pressure, Natural, Spherical Co-ordinates, UTM.). Scale analysis of the equation of motion. Geostrophic, quasi-geostrophic and hydrostatic approximations. Horizontal frictionless flow of balanced motions: Geostrophic flow, inertial flow, cyclostrophic flow and gradient flow. Thermal wind, barotropic and baroclinic atmosphere. Divergence and Vorticity theorems, their scale analyses. **Circulation and Vorticity**- Kelvin's theorem; The vorticity equation; Barotropic and Baroclinic potential vorticity (PV) equations; planetary vorticity, Absolute & potential vorticity conserving trajectories across mountain barriers; Kinematics of 2-D flows. Kinetic and Potential energy in atmospheric processes.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Fundamental forces in the atmosphere	15
Lecture Series 2	Equations governing the atmospheric motion	15
Lecture Series 3	Circulation and Vorticity	15
Total		**45**

Unit-wise learning outcome:

Students will have the knowledge of:

- The fundamental forces generating the atmospheric motion
- Equations governing the hydrodynamics of the atmosphere and the derived fields such as divergence and vorticity
- Theory of boundary layer and turbulence

Instruction strategy:
Lecture
Problem Practice in class
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
J. Holton. Introduction to dynamical meteorology Academic Press.
Ambaum, Thermal physics of the atmosphere, Wiley.
Hoskins & James, Fluid dynamics of the mid-latitude atmosphere,Wiley.
Hastenrath, Climate dynamics of the tropics. Kluwer.
George J. Haltiner and Frank. L. Martin, Dynamic and Physical Meteorology.
Maarten H. P. Ambaum, 2010: Thermal Physics of the Atmosphere (Wily). ISBN: 978-0-470-74515-1; 252 pages.
Dynamic and Physical Meteorology by George J Haltiner and Frank. L. Martin.

Course Name	**GIS and Remote Sensing**
Course Code & Number	**MetTh 209**
Course Type	**Theoretical**

Course Information

Course Credit and Marks	**03 (Three); Full Marks 100**
Rationale	A geographic information system (GIS) is a computer-based tool for mapping and analyzing feature events on earth. Remote sensing is the art and science of making measurements of the earth using sensors on airplanes or satellites.
Objectives	The objective is to integrate common database operations, such as query and statistical analysis, with maps by GIS technology. This course will provide tools to visualize, query, and overlay those databases in ways not possible with traditional spreadsheets which will ultimately help explaining and predicting various atmospheric events.
Learning Outcomes	Student will be able to access location specific Geographical information and display and analyze overlays of weather, climate and other geographical information and obtain various statistical and relational solutions using GIS. The Remote Sensing sensors on board satellites or aircrafts collecting data in the form of images willprovidespecializedinformation, which may be manipulated, analyzed, and visualized using Digital Image Processing systems.The course willallowthe students to link databases and maps to create dynamic displays. They will learn mapping of land use and land cover using remote sensing and geographical information systems (GIS).
Syllabus Content	Geographical Information System (GIS):Introduction to GIS: Components of GIS, Software, GUI, Symbolization and Map Design; Spatial and attribute data: Spatial Entities, Topology, Spatial Data Models (vector and raster), Data quality, Attribute Data Management; Acquisition and preprocessing of Geo-referenced Data: Coordinate Systems; Transformations and map projections; Digitizing, Editing and structuring map data; Primary data acquisition; Database Structures: Database approaches, Data models, Database Management Systems; Spatial Analysis: Organizing and classifying Geographic Data for analysis, Analysis of Spatial Data Remote Sensing: Introduction: Definition and Scope, Remote Sensing data acquisition, stages of remote sensing; Remote Sensing and EMR Interactions: Electromagnetic Radiation (EMR), Electromagnetic Spectrum, EMR Quantities, Radiant Energy, Radiant Flux, Irradiance, Emittance, Radiation Laws, Black-body Radiation, Interaction with Atmosphere, Atmospheric haze/aerosol, Scattering and Contrast Reduction, Spectral Signature, Hemispheric Reflectance, Transmittance and Absorption; Platforms, Sensors and Resolution: Platforms: Ground base, air borne, space borne, Sensors: Types of Sensors; Optical, Thermal, and microwave: sensor systems: Whiskbroom and push broom; Digital Image Processing (DIP): Concept of digital image, steps in DIP, Image corrections: radiometric, geometric and atmospheric corrections, Image registration; Image Classification-Unsupervised classification: techniques, advantage and disadvantage; Supervised classification: techniques, advantage and disadvantage

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Handling GIS database with relational data	20
Lecture Series 2	Remote Sensing Applications and Digital Data/Image Analyze using Digital Image Processing System	25
Total		**45**

Unit-wise learning outcome:

- Students will learn GIS and its application
- Students will also learn the Remote Sensing Technique as a tool for generating spatial data and information

Instruction strategy:
Lecture
Computer Laboratory
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):
ArcGIS manual
IBL Visual Weather Documentations
IBL Aero Weather Documentations
ERDAS Imagine and ENVI Image Processing Mannual
Digital Image Processing by Rafael C. Gonzalez
Algorithms for Image Processing and Computer Vision by James R. Parker
Fundamentals of Digital Image Processing: A Practical Approach with Examples in MATLAB (Paperback)by Chris Solomon
Image Processing by Henri Maitre
Principles of Digital Image Processing by Wilhelm Burger
Principles of Digital Image Processing: Advanced Methods by Wilhelm Burger
The Image Processing Handbook by John C. Russ
Fundamentals of Digital Image Processing by Anil K. Jain

Course Name	Programming Language - IV
Course Code & Number	MetLb 210
Course Type	Practical

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	The mathematical methods covered by this laboratory module are the core analytic methods that are useful for modeling the meteorological problems.
Objectives	An understanding of some of the techniques for solving ODES, PDEs numerically, and the considerations involved in choosing methods (stability, efficiency, obeying conservation laws, etc.).
Learning Outcomes	Students will have the knowledge to explain the different methods of data analysis and some computer programming in meteorology. They will be able to solve PDEs and meteorological phenomena related complex equations numerically.
Syllabus Content	• Introduction to Python: How to write, process and run Python programming. • Fourier Transform, Laplace Transform. • Greens Function with application to meteorology. • Laplace equations, diffusion equation and vorticity equation in atmospheric dynamics. • Problem solving in concurrent courses using Python programming.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Assessment of coefficients of transformation using Fourier, Laplace's etc.: 1.5 credit	25
Lecture Series 2	Solving PDE for solving Meteorological problems:1.5 credit	20
Total		**45**

Instruction strategy:

Lecture

Computer Laboratory

Live Streaming through website

Audio/Video Recording of the lectures

Recommended Text(s):

- Hans Fangohr, Introduction to Python for Computational Science and Engineering.
- Johnny Wei-Bing Lin, Environmental Data Analysis with Python
- Kelsey Brunner, Hands-On Meteorological and Oceanographic Data Analysis with Python

Course Name	GIS and Remote Sensing Lab + Field
Course Code & Number	MetLb 211
Course Type	Practical

Course Information

Course Credit and Marks	03 (Three); Full Marks 100
Rationale	Remote sensing provides us with a continuous and constant source of information about the Earth, and geographic information systems (GIS) are a methodology for handling all of this geographic data. The marriage of the two disciplines has allowed us to carry out large scale analyses of the Earth's surface and, at the same time, provide increasingly detailed knowledge on many planetary variables and improve our understanding of its functioning.
Objectives	This is invaluable to monitor the earth's resources and assess the effect of human activity on them. Remote sensing systems deployed on Satellites provide repetitive and consistent view of the earth. These analyses are essential for decision-making on the sustainable management of natural resources, designing networks of protected areas, and addressing the threats of global change.
Learning Outcomes	Students will learn create spatial and attribute data, which are geographically connected and will learn manipulate for decision making in earth sciences including climatic areas.
Syllabus Content	**Geographic Information System:** Building Geo data base: Build, Modify, Join Tables, Aggregate, Export other ArcCatalog utilities; Importing Spatial and Attribute Data: Sources of Maps and Data, Vector Spatial Data Format, Identify and Change Projections, Examine Metadata, View Attribute Data. Digitizing: Digitize and Edit Polygon layer, digitize a Point Layer, digitize a Line layer, spatially adjust features. Spatial Data Processing: Extract, Clip, Union, Dissolve, Append layers, Model Builder Map layout: Creating Maps, Symbolizing Data, Labeling Maps, Graphs, Laying out and Printing Maps **Remote sensing:** Introduction with remote sensing software; Remote sensing data acquisition process; Spectral signature of soil, water and vegetation, Composition of True Color Image and False Color Image, Image registration, Radiometric and geometric corrections of image, Image Enhancement, Image Classification, Image Analysis, Interpretation and composition of thematic maps.

LESSON PLAN

Lecture sessions	Topics	Number of Classes
Lecture Series 1	Labs with GIS	20
Lecture Series 2	Lab Sessions with RS	25
Total		**45**

Unit-wise Learning Outcome:

- Students will learn create spatial and attribute data, which are geographically connected
- and will learn to extract, process and manipulate remote sensing data for decision making in earth sciences including weather and climate areas.

Instruction strategy:

Lecture
Computer Laboratory
Live Streaming through website
Audio/Video Recording of the lectures

Recommended Text(s):

ArcGIS manual
ERDAS Imagine and ENVI Image Processing Manual
IBL Visual Weather Documentations
IBL Aero Weather Documentations
Digital Image Processing by Rafael C. Gonzalez
Algorithms for Image Processing and Computer Visionby James R. Parker
Fundamentals of Digital Image Processing: A Practical Approach With Examples In Matlabby Chris Solomon
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The Image Processing Handbook by John C. Russ
Fundamentals of Digital Image Processing by Anil K. Jain

Course Name	**Viva-voce**
Course Code & Number	**MetV 212**
Course Type	

Course Information

Course Credit and Marks	**02 (Two); Full Marks 100**

Viva-voce : All students will have a viva examination on Project work: They will prepare a power point presentation and present it before a board of experts.