

**METEOROLOGICAL RESEARCH AND TRAINING INSTITUTE  
(A WMO RMTC)  
OSHODI – LAGOS, NIGERIA**

**SYLLABUS FOR JOB – ENTRY LEVEL  
METEOROLOGICAL TECHNICAL COURSE**

## **ALGEBRA**

1. Simultaneous equations: Linear and quadratic.
2. Indices.
3. Logarithms: Natural and any base.
4. Quadratics equations: Algebraic & graphical solutions, roots of quadratics.
5. Variations: Linear, Inverse, joint and partial.
6. Inequalities: Linear and quadratic.
7. Polynomials: Factor theorem; Remainder's Theorem; Paschal Triangle.
8. Series and Progression.

## **PHYSICS (MECHANICS & PROPERTIES OF MATTER)**

1. Units and dimensions of physical quantities.
2. Vector and scalar quantities.
3. Linear motion of a particle: equations of motion with uniform acceleration.
4. Newton's Laws of motion
5. Pressure.
6. Density.
7. Introduction to circular motion and Simple Harmonic Motion.

## **UPPER-WIND MEASUREMENTS AND PILOT – BALLON**

1. General – Units of measurements.
  - 1.1 Meteorological balloons: There are three types of balloon colours in use for the measurement of upper wind:- Red, blue and colour. The state of the sky determines the colour of balloon to be used.
  - 1.2 Gases for inflation of Meteorological balloon helium, or hydrogen gas.
  - 1.3 Hydrogen generators for Meteorological purposes.
  - 1.4 Theory of upper-wind measurement.
  - 1.5 Care and handling of Meteorological balloons.
  - 1.5.1 Sizes of Meteorological balloons
  - 1.6 The Pilot – Balloon theodolite.
  - 1.6.1 Pilot – balloon ceiling measurement for the determination of cloud – base (Height).
2. Pilot Balloon Codes PART A, B, C, D,
3. Temp Message  
Message Identifier TTAA  
Digikora, Radio Sonde Transmitter  
The weather elements observed are: Pressure, Temperature, Wind direction and speed, humidity and dew point.
4. Radio sounding of the upper atmosphere  
General – units of measurement  
Principle of the radio sounding system, Principle of the radio sounding and ascent evaluation.

## **METEOROLOGICAL INSTRUMENTS**

1. Measurement of meteorological variables
  - 1.1 Specific features of Meteorological Measurement
  - 1.2 Direct and indirect Meteorological measurement  
Direct Reading Instruments:  
Thermometers, Barometer, Wind Vane, Cup-Counter Anemometer, Class A Pa, Gunn Bellani Radiation Integrator, Rainguage, Sunshine Recorder, and Ordinary Anemometer.  
Indirect Reading Instruments: Thermo graph, Barograph, Hyetograph and Hygrograph.
  - 1.3 Desirable Characteristics of Meteorological Instruments,
  - 1.4 General requirements for siting and exposure of Meteorological Instruments.
2. Measurement of atmospheric pressure
  - 2.1 Nature of atmospheric pressure – Units of measurements
  - 2.2 Principles underlying the operation of atmospheric pressure measuring Instruments

- 2.3 Mercury barometers; Kew Pattern Barometer and Fortins Barometer
- 2.4 Aneroid barometers; analogue and digital; read – out the barograph
- 2.5 Exposure of atmospheric pressure measuring instruments.
  
- 3.0 Measurement of air temperature
- 3.1 Nature and units of measurement of air temperature, temperature scales used in Meteorology and conversion.
- 3.2 Principles underlying the operation of air – temperature measuring Instruments; Mercury-in-glass thermometers, spirit-In-glass thermometers The bimetallic thermometers, station thermograph
- 3.3 Exposure of air temperature measuring instruments – radiation errors.
- 3.4 Setting time of thermometers.
  
- 4.0 Measurement of atmospheric humidity
- 4.1 Nature and units of measurement of absolute humidity, relative humidity and dew point – and other humidity parameters.
- 4.2 General principles of hygrometers.  
Humidity measuring instruments based on change of dimension of Hygroscopic substances- the hair hygrometer, the psychrometer.  
Remote – reading and recording psychrometer.
- 5.0 Measurement of surface wind direction and speed
- 5.1 Wind direction and wind speed – specific feature units of measurement
  
- 5.2 Principles of wind measuring instruments;  
The pressure plate anemometer  
The rotation sensor cup – wheel – propeller.  
Anemometers measuring run of wind.
  
- 6.0 Measurement of precipitation
- 6.1 General liquid and solid precipitation – units of measurement
- 6.2 Principles of the Point measurement of precipitation.  
Non – recording precipitation gauges – daily rain gauges of the unshielded and shaded types.  
Recording precipitation gauges – siphon (float type – tipping – bucket – Weighing – balance type  
Exposure requirements concerning precipitation point – measurement instruments.
- 6.3 Routine care of precipitation measuring instruments
- 6.4 Factors affecting the accuracy of point – precipitation measurements  
Evaporation Loss
- 7. Measurement of evaporation
- 7.1 General units of measurements, Principles of evaporation measuring Instruments, the evaporation pan: Class A Pan – the hooked – gauge type
- 7.2 General requirements for the evaporation – measuring instruments' exposure, routine care of evaporation – measuring instrument.
- 8.0 Sunshine duration measurement  
General principles of sunshine duration measurement

- The Campbell Stokes sunshine duration recorders
- 8.1 Siting and exposure requirements for sunshine duration measuring Instruments, factors affecting the sunshine records of the Campbell Stokes instrument.
  - 8.2 Routine care of the Campbell Stokes sunshine recorder – measurement of burn trace on the cards.
  - 9.0 Automation of the measurement of Meteorological variables.
  - 9.1 Technical and economic aspects of automation objectives.
  - 9.2 Classification of automatic weather stations.
  - 9.3 Basic block diagram of an automatic weather station.
  - 9.4 Sensors used with automatic weather stations.
  - 9.5 Maintenance of automatic weather stations
  - 9.6 Reliability of automatic equipment

## **CODES AND OBSERVATIONS**

1. Measurement of meteorological variables and procedure of observation  
Specific features of Meteorological measurements; Direct and Indirect.  
Measurement of Temperatures; Air, Maximum, Minimum etc.  
Measurement of Humidity; Relative Humidity autographic instruments,  
Derived values with aid of Humidity slide rule, Measurement of Atmospheric Pressures (Barometers,) Barographs).
2. Measurement of Clouds;  
Forms, Types, Amount, Height of base (Ceilometers, ceiling Ascent, Cloud Atlas and Pictures)
3. Measurement of surface Winds.  
Direction and speed; (Anemometers, and Beaufort scale for estimation).
4. Precipitation Measurements (Rates and Records of precipitation) Solid or Liquid, Gauges units.
5. Measurement of Evaporation – Piche Evaporimeters
6. Visibility; General unit measurements, Definition of visibility parameters, Visibility at night
7. Measurement of solar and radiation (Sunshine recorders, cards and Integrators).
8. Methods and procedures of observations  
Standard time, accuracy and measurement (UTC unit)  
Standard International Block and stations numbers e.g. Nigerian Stations

9. Codes  
Applications of SYNOP code for observation Section O -5  
Cloud; Type, form, height of base, Present eather, Visibility  
Ind (Direction and speed), Precipitation (Amount and Duration).  
Application of METAR and SPECI Codes. Application of Question Codes.

## **PLOTTING**

1. Data representation on chart  
Data is represented on charts with international symbols  
Surface Plotting model, Ship message plotting model.  
Tables;  
Table I Wind direction and speed  
Table II Clouds and pressure tendencies  
Table III Present weather symbols
2. Locations of station on Charts
3. Application of models and tables.

## **AGROMETEOROLOGY**

1. Definition, scope and aims of Agrometeorology  
The relationship between weather, climate and agriculture as it affects soil, plants, farm animals, pests and diseases.
2. Artificial modifications of the Meteorological and Hydrological regimes  
Namely; glass green houses, windbreaks, and shelter belts, irrigation  
Mulching.
3. Prevention and mitigation of Agrometeorological calamities in Nigeria.
4. Evapotransition Studies  
Agrometeorological water balance  
 $P + I = ET + R + D + S$   
Evaporation  
Evapotranspiration (Actual and Potential)  
Factors affecting evapotranspiration  
Factors affecting evapotranspiration  
Calculation and Measurements of evapotranspiration  
Water balance: Lysimetry  
Aerodynamic profile approach (Bowen into  
Combination methods (Penman equation)  
The use of evapotranspiration data.

5. Soil Water
  - Soil water availability
  - 3 categories of soil water
    - Capillary
    - Hygroscopic
    - Gravitational
  - Field capacity
  - Wilting point
  - Soil water in relation to plant growth.
  - Plant response to water deficit and excess moisture
  - The need for soil Moisture
  
- 6.0 Biological Observations (Phenological observations)
  - Phonological phases in cereals
  - Germination
  - Emergence
  - sprouting
  - Tillering
  - flowering
  - earning
  - milky ripeness
  - waxy ripeness
  - Tisselling

Importance of phonological observations

Observations on crop pests and diseases

Factors affecting disease development and propagation (the role of the Macro-climatic environment) namely, temp, humidity, soil pH, wind, soil Texture.

Control of plant diseases

Cultural methods

- . Proper selection of geographical area
- . Selection of field
- . Choice of time of sowing

Exclusion method

Eradication

- . Rogueing
- . Crop sanitation
- . Eradication of alternate and collateral hosts
- . Heat and Chemical treatments of diseased plants
- . Biological control

7. Pests of Crop plants

Insect pests (the classification based on habits and parts of plants attached)

barriers, sucking insects, leaf eating insects, fruit and seed eaters etc.

- Other Pests
  - Birds
  - Rodents
  - Monkeys
- 8. Diseases of Crop Plants
  - Fungal diseases
  - Bacterial diseases
  - Viral diseases
- 9. Poultry diseases
  - Symptoms and control
- 10. Agrometeorological stations
  - Classification
    - Principal
    - Ordinary
    - Auxillary
  - Agromet station for specific purposes

## **STATISTICS**

1. Introduction:  
Definitions, meaning of statistics, examples with natural situations. Data collection and storage.
2. Data arrangement:  
Mean, median, mode; Mean of grouped and ungrouped data. Assumed Mean. Arithmetic and Geometric mean. Median and mode for grouped data Average mark.
3. Graphical representation of data:  
Pie chart, bar chart, Frequency table, cumulative frequency, Ogive.
4. Probability:  
Classical, subjective, relative frequency approach. Equally likely events, Mutually exclusive events, independent events.
5. Applications:  
Daily and monthly means of weather elements like temperature, pressure, Humidity etc.

## GENERAL METEOROLOGY

1. The composition of the atmosphere: dry air; atmospheric ozone; water Vapour; carbon dioxide; thermosphere; interplanetary gas; Vertical divisions of the atmosphere; troposphere; stratosphere; mesosphere; thermosphere; ionosphere exosphere.
2. Heat exchange processes in the atmosphere; solar and terrestrial radiation; Conduction and convection; advection; mechanical and thermal turbulence (or Thermo-convection); energy budget of the atmosphere; effect of radiation at the earth's surface; temperature difference between land and sea surfaces.
3. Air temperature; basic principles of temperature measurements; Celsius, Fahrenheit and Kelvin temperature scales, Thermometers, physical processes Used in thermometry, types; thermograph, principles of design, measurement Of air temperature; exposure; horizontal and vertical variations of air Temperature, troposphere, tropopause and stratosphere
4. The effect of gravity on the atmosphere, air density, Atmospheric pressure, Nature; units; measurement; the hydrostatic equation; the mercury Barometer; its principle; setting up and handling; corrections for standard Condition; the aneroid barometer; the barograph; horizontal and vertical Variation in pressure; pressure to sea level; the ICAO Standard atmosphere; the barometer used as an altimeter; semi-diurnal Variation of pressure; significance of pressure gradient
5. Moist air; the three states of water, solid, liquid and gaseous; density; Water vapour pressure; saturation vapour pressure; evaporation Condensation; freezing; sublimation; isobaric and adiabatic processes; latent Heat
6. Moisture indicators; relative humidity; mixing ratio and dew point; water Vapour pressure
7. Elementary theory of the wet-bulb thermometer; principles of the psychrometer and the hygrometer; rudiments of cloud, fog and precipitation formation; visibility, the influence of water vapour, of water drops and dust (aerosols)
8. Expansion or compression of a rising or falling air bubble; variation of the bubble's temperature with height; isobaric expansion and adiabatic expansion; the influence of condensation; basic knowledge of the vertical stability or instability; non-saturated air and saturated air.
9. Elementary knowledge of synoptic and dynamic meteorology; air motion;

Significance of scale; the winds and their causes; rudiments of the General circulation in the tropics and in non-tropical regions; local winds; diurnal wind variation (breezes) and annual wind variations (monsoons); relation between the horizontal pressure gradient and the Winds; Buys-Ballot's law and the geostrophic wind; cyclones and Anticyclones; air masses and fronts; thunderstorms; synoptic chart analyses; Weather associated with synoptic systems.

## **DIFFERENTIAL AND INTEGRAL CALCULUS**

1. Differentiation; The idea of a limit; the derivative of a function; its meaning and its determination from first principles in simple cases, e.g.  $x^2$ ,  $1/x$ ; Differentiation of  $ax^n$  for integral and of sums and differences of such expressions; Gradient of a curve determined by differentiation; determination of greatest and least values; curve sketching turning points (Maxima and minima only); applications to problems involving small Changes and rates of changes; Derivatives of  $\sin x$ ,  $\tan x$ ,  $\cot x$ ,  $\sec x$  and  $\operatorname{Cosec} x$  Tangents Normals;
2. Integration; The definite integral and its representation as an area; Approximate evaluation of integrals; integration of  $ax^n$  for integral  $n$  and of sums and differences of such expressions.

## **PHYSICS (HEAT)**

1. Concept of heat, heat sources, temperature and temperature scales
2. Thermometers: liquid-in-glass, gas and electrical thermometers
3. Effect of heat on matter: solids, liquids and gases.  
solids: thermal expansion – linear, area and volume  
liquids: apparent, real and absolute; expansion of water  
gases: adiabatic
4. Application: bimetallic strips  
heat capacity, specific heat capacity and calorimetry  
land and sea breezes, phase change, latent heat

5. Heat transfer: conduction, convection and radiation  
Solar and terrestrial radiation, temperature profile of the atmosphere
  
6. Gas laws: Boyles, Charles, pressure and Dalton's law
  
7. Kinetic theory of gases  
boiling, evaporation, condensation, vapour pressure  
Introduction to cloud formation, weather and climate, green house  
Effect, global warming and heat discomfort.

## **AERONAUTICAL METEOROLOGY**

1. Observing techniques. Surface wind direction and speed, including changes and variations. Visibility and runway visual range, including spatial and temporal variations in RVR OBSERVATIONS, Cloud amount, height and type and spatial and temporal variations; vertical visibility, observations using automatic instruments such as a cellometer. Pressure measurements for the purpose of determining QFE and QNH.
  
2. Hazardous phenomena. Aircraft icing; elementary knowledge of icing types; formation, accretion rates and association of icing with clouds, Turbulence, elementary knowledge of turbulence near the ground as Related to topography, Elementary knowledge of high-level turbulence (CAT) and its association with jet streams, wind shear, volcanic ash.
  
3. Reporting, coding and dissemination of weather information. Complete Knowledge of international meteorological codes related to observations, Such as METAR, SPECI, SYNOP, PILOT, and TEMP. Knowledge of Procedures for dissemination of weather information at the aerodrome, Including the special needs of ATC units, Knowledge of the procedures for the preparation of the plain language forms of meteorological messages.
  
4. Definitions. Meteorological report, observation, visibility, runway visual range. Altitude, elevation, height, aerodrome elevation, flight level, transition level. Aerodrome meteorological minima, instrument runway, landing area.
  
5. Procedures for meteorological services for international aviation, Organization of the meteorological service and particularly the functions of the various types of meteorological offices. Aeronautical meteorological stations and their functions, local routine and special observations and reports, reports, in METAR and SPECI code forms. Meteorological watch.

Introduction to the responsibilities of ICAO and WMO in aeronautical Meteorology.

6. Air traffic services. Demands for meteorological services, including the Types of meteorological information required by the various air traffic Services units and the updating of this information by means of duplicate displays in ATS units or by prompt data transmission originated by the meteorological office or station.
7. Operation of aircraft. Flight planning, Duties of flight operations officers When exercising operational control. Navigation and landing aids. Effects Of air density, icing, turbulence, wind, wind shear and volcanic ash on Aircraft performance. Altimeter setting procedures, standard atmosphere. Performance characteristics, including fuel consumption of civil aviation Aircraft; characteristic of propeller type, turbo-prop and turbo-jet and, Where applicable, supersonic aircraft. Effects of various weather phenomena on aeronautical operations and on aerodrome ground services.
8. Aeronautical telecommunications. Elementary understanding of the General organization of aeronautical telecommunications, but they should Have a good working knowledge of the operation of the aeronautical fixed Service.
9. WMO documents. Technical Regulations, (WMO-No. 49) Vol. 11 – Meteorological service for International Air Navigation. Manual on codes WMO-No 306). Guide to Meteorological Instruments and Methods of Observation (WMO-No 8). Weather Reporting (WMO-No 9).

**MEDIUM LEVEL  
METEOROLOGICAL  
TECHNICIANS'S IN  
TRAINING  
(CLASS III)  
CURRICULUM**

**PHYSICAL METEOROLOGY**

1. Introduction to the subject
2. Definitions, Clouds, Fog and precipitation: basic knowledge of their Formation;
3. Condensation nuclei;
4. Influence of the surface tension of rain drops and of the hygroscopicity of nuclei on saturation pressure;
5. Process of raindrop formation;
- 6 Large-scale and small-scale cooling of the air due o adiabatic and non-Adiabatic processes;
7. Frontal generally stratiform cloud up-draught on the synoptic scale.
8. Cumuliform clouds thermal up-draught.
9. Orographic clouds;
10. International cloud classification,
11. Fog Classification,
12. Meteors,
13. Artificial rain.
14. Elements of Atmospheric Optics and Electricity, Refraction, Rainbow, Halo, Corona Blue of the sky,
15. Transparency of the atmosphere and visibility;
16. Application of motions of Static electricity of the electric field of the atmosphere.
- 17 Atmospheric ions and the Conductivity of the air;
18. Lightning discharge and thunderstorms.
19. Exercises

## **DIFFERENTIAL & INTEGRAL CALCULS**

1. Continuous function of a variable derived from a continuous Differential Function.
2. Derivative of sum, difference, product and quotient of two functions; Implicit functions.
3. Derivations of  $x^n$  ( $n \neq 0$ ), trigonometric functions.
4. Compound angles.
5. Applications of derivatives: Stationery values; maximum, Minimum and of a point of inflexion function of a variable; tangents and normal to a curve at a point; movement of a point on a straight line, velocity and acceleration.
6. Theories on circle.
7. Partial fractions.
8. Integration:  $x^n$ ,  $(ax + b)^n$ , trigonometric functions.
9. Applications of integration: area under a curve; the axis of the abscissae and ordinate of the end points of the arc; lateral area and volume of a body of revolution.
10. Conic Section: the Parabola, Ellipse and Hyperbola.

### **PHYSICS (MECHANICS & PROPERTIES OF MATTER)**

1. Work and energy; momentum; Principles of conservation of energy; Principle of conservation of momentum, coefficient of restitution
2. Dynamics of rigid bodies; moment of inertia; radius of gyration; Translational and Rotational energy; compound pendulum.
3. Motion of a body falling under gravity.
4. Friction.
5. Elasticity
6. Viscosity
7. Hydrostatics
8. Surface tension.
9. Simple harmonic motion: vibration of a spiral spring, Elastic string.

### **DYNAMIC METEOROLOGY**

1. Concept of dynamic meteorology compared with synoptic and physical meteorology, physical dimensions and units.
2. Atmospheric scales; pressure gradient, gravitational, centrifugal, gravity and coriolis forces, equation of motion in a simple form, geostrophic wind, wind and pressure near the equator; gradient wind and comparison with geostrophic wind, trajectories and streamlines, cyclostrophic wind; flow within the planetary boundary layer (cross-isobaric flow)
3. Ageostrophic and isallobaric winds, hydrostatic equilibrium and hypsometric equation and uses, thermal wind, divergence, convergence and vertical motion, intensification and deepening of pressure systems, vorticity (relative and absolute), formation of cyclones and anti cyclones; turbulence and gustiness, eddies and vertical transport of matter, clear-air turbulence.

## **THERMODYNAMICS**

1. Gas laws  
Boyle's and Charle's Laws, Dalton's Law of partial pressures, Ideal gas law. Equation of state for dry and moist air, Mixture of gases.
2. Adiabatic processes  
Definitions, Dry, Moist and Pseudo – adiabatic processes. Equations for Adiabatic processes, Dry, moist and saturated adiabatic lapse rates. Poisson Equation and potential temperature. Latent heat of condensation.
3. Conservation of energy  
First law of thermodynamics system, change of phase and latent heat. Reversible and irreversible processes.
4. Hydrostatic stability  
Convection. Comparison of magnitudes of different lapse rates. Methods of Determining stability – parcel and slice methods. Hydrostatic balance, Potential energy, Geopotential metre and geopotential height.
5. Moisture variables  
Definitions and meanings of Potential temperature, vapour pressure, mixing Ratio, absolute humidity, equivalent potential temperature, saturation mixing Ration, absolute humidity, dew point temperature, specific humidity, virtual Temperature etc.
6. Types of atmosphere  
Homogeneous, Isothermal, constant lapse rate and dry adiabatic

Atmospheres.

7. Second law of thermodynamics  
Entropy of a system, Entropy change as a function of potential temperature.  
Irreversibility –concept of statement of second law of thermodynamics.
8. Thermodynamic cycle  
Carnot cycle, Isothermal and adiabatic expansion and compression.

## STATISTICS

### 1. Regression and Correlation

Scatter graphs , Relationships between two variables and scatter graphs  
(Construction, line of best fit, estimate from scatter graphs significance of  
The scatter graph, limitations of scatter graph)

Regression lines (definition, equations of approximating curves i.e.  
Exponential and polynomial curves); computing regression lines (equation  
Of the line or straight line; method of least squares, measuring the  
Deviations; the regression of y on x; the regression of x on y; graphing  
Regression lines; the use of regression lines; choice of regression line and  
Regression coefficient)

Correlation (computation of r; interpretation of r; types of correlation;  
Spurious correlation; Rank correlation  $r^1$ .  
Applications to time series graphing the data; the equation of a least  
Square line and fitting the data; estimates.  
Multiple linear regression and non-linear regression.

### 2. Probability

Introduction: Definitions of probability, events and various classes of  
Events; trials and random variables and probability symbols.  
Conditional probability; independent and dependent event; mutually exclusive events;  
Mathematical expectation; permutations and combination. Probability distributions, the  
Binomial distribution (a short-cut i.e.  $P(X) = nC_x P^x q^{(n-x)}$ , when can it be used, mean  
And standard deviation of Binomial distribution, some properties, the  
Poisson distribution (Poisson distribution, when it can be used, mean and  
Standard deviation of the Poisson distribution and some properties and the  
Normal distribution some properties of the Normal distribution, the relation between  
Binomial and normal distribution.

### 3. Estimation

Tests of significance; testing a hypothesis (the null hypothesis, testing the  
Null hypothesis, rejection of the null hypothesis, non-rejection of the

Null hypothesis, confidence level and the risk of rejecting a true hypothesis, Confidence level and the risk of not rejecting an incorrect hypothesis; type I and II errors; one-tail and two-tail tests. Testing different between means and properties (Distribution of the difference between properties).

4. Small Sampling Theory  
Small Samples; “Student’s” t-distribution, confidence intervals;  
Test of hypothesis and significance; the chi-square distribution;  
Confidence intervals for  $\chi^2$  degree of freedom.

## **MARINE METEOROLOGY**

1. Introduction
  - General introduction of marine meteorology.
  - Water coverage, Air-Sea interaction.
  - Marine meteorology variables.
  - Uses of marine meteorology information etc.
2. Marine Meteorology Service [MMS]
  - Purpose and principles of MMS.
  - Data acquisition, Voluntary Observing Ship (VOS) and Ship of Opportunity (SOO)
  - Mobile and fixed Sea Stations.
3. Components of MMS
  - Services to high sea,
  - Services to control and offshore areas;
  - Services to Main ports and harbours; Port Meteorological Officer,
  - Training in field of Marine meteorology
4. Observation
  - Important of marine meteorological observation.
  - Marine meteorological variables: Definition, general Description of the variables and their importance.
  - Visibility at sea.
  - Dissemination of marine meteorological information.
5. The Ocean and Measurement of Current
  - Oceans and their Dimensions
  - Hydrostatic pressure, illumination and temperature of the Ocean,
  - Thermoclines.

- Salinity and its measurements.
  - Ocean Current; Definition and methods of measurement.
6. Sea Surface Temperature [SST] and its sub Surface Temperature. (S.S.T).
- Definition and uses of Sea Surface Temperature. (SST).
  - Methods of measurement of SST.
  - Diurnal and horizontal variation of SST.
  - Influence of SST on weather
  - Effects of temperature on marine life.
  - Measurement of Sub Surface Temperature (Bathythermograph and reversing thermometer).
7. Marine Meteorological Codes and Ship messages
- Need for codes, marine meteorological log book.
  - Ship messages: Selected, Supplementary and Auxiliary ship Messages.
  - Marine Meteorological coding and decoding.
8. Ocean Waves
- Atmosphere Turbulence, Sea Waves, Swells and Waves Characteristics.
  - Wave formation and growth.
  - Relationship among wave characteristics in deep and shallow water
  - Wave measurement [wave recorder].
  - Measurement of sea state: Beaufort's scale and its limitations.
  - Storm surges, tides, tidal waves etc.
  - Coastal up welling.
9. EL NINO/Southern Oscillation [ENSO]
- Description and causes of EL NINO, LA NINA and Southern Oscillation.
  - Influence of EL NINO global weather pattern.

#### Special Topics

Role of Marine Meteorological services in life saving, rescue operations and pollution Monitoring.

#### Sea level change

- Relationship between climates and sea level change.
- Climate and tectonic factors responsible for global sea level rise.
- Temporal variability.
- Estimation of sea level change

## CLIMATOLOGY

1. Introduction
  - Clear distinction between weather and climate
  - Techniques usually adopted in climatology
  - Factors which can affect or modify the climate of a place using Nigeria in West Africa for illustration of the effect
  - Climatological elements. All elements of weather should be discussed, but emphasis on those which actually shape the climate of a place e.g. temperature (including radiation), winds humidity (including rainfall and air mass structure in the area)
2. The climatic regions of the world. The role of air masses in determining the major climatic regions of the world.
3. The climate of Nigeria
  - The ITCZ- Definition and its seasonal movement. Its role in determining the climate of various places in Nigeria on a meridional axis.
4. The seasons in Nigeria
  - The length of the rainy and dry seasons in Nigeria
  - Approximate on-set dates (months) for the two major seasons in Nigeria (a) Rainy season and (b) dry season.
  - Reasons for the variation of the on-set dates in Nigeria.
  - The two seasons in Nigeria; the prevailing winds and principal air masses associated with each season. Relationship between winds and air masses.
5. Weather zones in Nigeria
  - Climatological characteristics of each zone. Basis for the existence of the weather zones. Seasonal persistence of the zones on spatial basis (e.g. frequency distribution of the zones in Nigeria)
6. Classification of climates: the Greek classification-empirical and genetic classifications; reasons for classifying climate. Köppen's classification, Thornthwaite, Miller.
7. Climatological system: components of; climatological system as far as the climate of Nigeria is concerned; anthropogenic impact on the climate system in Nigeria.
8. Regional climatology: geographical distribution of climates, Climatology.
  - monsoon climate with definite seasonal pattern (wet and dry tropics)
  - tropical climate
  - tropical arid and semi arid climates
  - temperate climate
  - polar climate

tundra, taiga  
topoclimate

9. Climatic scales  
Macro, meso, microclimates. General principles, types and concepts  
Astronomical, physical and geographical factors of climates  
Processing of climatological data – application of statistical method.
10. African climate  
Climatology of basic meteorological systems for the African continent especially on a N – S axis in West Africa and central Africa.  
The monsoons of the world with specific reference to West Africa, east Africa and India.

## **ELECTRICITY**

1. Electrostatics:  
Positive and negative charges, Conductors and insulators. Coulomb's Law, Permittivity, Economic importance.
2. Electric fields:  
Equipotentials, Potential due to a point charge and conducting sphere. Field Strength, electric potential, potential gradient.
3. Chemical effect of current:  
Ohm's law, resistance in series and parallel, potential difference, internal Resistance and loads. Primary and secondary cells; polarization.
4. Heating effect of current:  
Electrical energy and power. Mechanism of heating effect. Theory of heat Conduction; Power rating of resistors, high tension transmission.
5. Electromagnetism:  
Magnetic field – straight wire, circular coil and solenoid. Biot -savart law. Force on a conductor; Fleming's rule, cork screw rule. Moving coil Instruments; couple in a magnetic field.
6. Electromagnetic induction:  
Lenz's law; magnitude of E.M.F.; flux linkages; induction coil. Applications of Induction – Dynamos, generators and the transformer. Eddy currents; Alternating currents; back E.M.F.

## **CLIMATOLOGICAL RETURNS**

1. Climatological returns; Its meaning; importance; qualities;  
Types of forms; Form Met.100; Form Met. 101, Form Met. 10; Form Met. 103, Form Met. 104; Form Met. 113; Form Met. 120; Form Met. 130; Form Met. 131; Form Met. 135; Form Met. 141 Form Met. 143; Form Met. 145; Form Met. 146; Form Met. 147; Form Met. 509; Form Met. 4520; Form Met. 4521; Form Met.4522; Compilation; Computation; Missing data
2. Climatological returns form and usage  
Autographic chart analysis and entries into appropriate form  
Estimation and entries of missing records using the autographic records and eye readings.  
Extraction of meteorological data from climatological returns  
Checking of Climatological returns.

## **AGRO-METEOROLOGY**

1. Introduction
2. Agronomic Concepts of the Physically-defined Growing Season.
3. Calculation of Potential Evapotranspiration and Evaporation over Water Surface using Penman method.  
Practical comparison of actual Potential Evapotranspiration (PET)  
Evaporation in the observatory with calculated values using Penman method.  
Practical evaluation of soil Moisture values using the direct and indirect Methods.
4. Crop Forecasting Methods  
The Crop forecasting method based on Agro Meteorological Information  
The Crop forecasting method based on statistical analysis.
5. Practicals  
Effect of amount of weather elements on Crop yields (e.g. Maize, Cassava, Tomatoes, Cabbage, Pea-nuts, water Melon e.t.c)  
Effect of spacing on Maize Crop yield.  
Effect of controlled environment on Crop yield.  
Analysis of Crop yield variation to different weather elements.

## **SYNOPTIC METEOROLOGY**

1. Overview of meteorological observations and measurements; Physical Principles used in instruments to measure temperature, moisture, pressure, precipitation, wind, sunshine and radiation. Synoptic data Surface, upper-air and special observations, coding and decoding, representation and analysis of meteorological data; quality control. Global observing system; World weather watch programme; global meteorological telecommunications network;
2. Mid-latitude synoptic systems. Air-mass concept; source areas; formation processes for air-masses. Air-mass modification; thermodynamic and dynamic changes; boundary/interface between two adjacent air masses; the slope of steady-state frontal zones; frontal-wave depression.
3. Tropical Weather systems. Trade inversions trade winds, Tropical/subtropical jet streams, and other broad wind systems. Rainfall, Tropical cyclones, monsoons. Characteristic patterns of cloud associated With easterly waves, seasonal evolution of the tropical wind systems, and the inter-tropical convergence zone; annual cycles. Synoptic analysis of the disturbance patterns at the surface and their relation to high-altitude feature.
4. ITCZ and the associated weather zones. Waves and jet streams, Sea breeze, anabatic and Katabatic winds.
5. General circulation and the pressure systems.

## **SYNOPTIC METEOROLOGICAL PRACTICALS**

1. Definition of Analysis  
Composition/Design of Various Charts  
Importance of the above to Science of Meteorology
2. Types of elements and the Charts used  
Rules governing Analysis/Nature of Analysis  
Types of Analysis and available  
    Surface  
    Upper Air  
    Frontal
3. The Tephigram chart
4. Practical Exercises.

## **CODES AND OBSERVATION**

- ❖ INTRODUCTION TO “9” SPECIAL PHENOMENON GROUPS I.E. 9SPSPSPSP OF SYNOPTIC MESSAGE
- ❖ INTRODUCTION TO SUPPLEMENTARY INFORMATION GROUPS OF SYNOPTIC MESSAGE E.G 5J1J2J3J4, 4FFFF, 55408, 4ESSS ETC.
- ❖ SECTION 5 555 OF SYNOPTIC MESSAGE E.G. 1snTXTXTX  
2snTnTnTn 30UUU 40RRR
- ❖ METAR MODIFICATIONS AND CORRECTIONS
- ❖ SPECI MODIFICATIONS AND CORRECTIONS
- ❖ PREVAILING VISIBILITY/ DIRECTIONAL VISIBILITY

## **COMPUTER STUDIES**

1. Evolution of the computer systems: Definitions of computer; History of the computer (The beginning of computer age); Generations of computers; Types of computers; Classifications of digital computers; Characteristics of computers; Application of computers in the society.
2. Functional parts of a digital computer: Hardware (Input units, Output units, Processing units, Storage units, Communication units) and software (types of computer software, operating system, application software).
3. Computer Safety And Maintenance (Top Computer Mistakes Beginners Make, Basic Troubleshooting Techniques, Maintaining Your Computer).
4. Using the computer (Buttons and parts on a computer, Setting up a computer, Computer safety and maintenance).
5. Introduction To Data Transmission And Computer Networking (Data Transmission, Data Transmission And Communication Facilities, Computer Network, Types Of Network, Network Configurations, The Internet And The Electronic Mail).
6. Introduction To Computer Programming (Flowchart And Algorithm, Introduction To The BASIC Programming Language)

METEOROLOGICAL RESEARCH AND TRAINING INSTITUTRE  
(A WMO RMTC)  
OSHODI – LAGOS, NIGERIA

**SYLLABUS FOR SENIOR LEVEL METEOROLOGICAL  
TECHNICIAN COURSE**

## DYNAMIC METEOROLOGY

1. Atmospheric scales, Discussions on pressure gradient, gravitational, frictional, centrifugal, Gravity and Coriolis forces, total local derivatives, transformation from non-rotating co-ordinate system; equation of motion in vector form as derived from Newton's second law, Equation of motion in spherical co-ordinates (tangent plane approximation); scale analysis leading to simplified equations.
2. Introduction to hydrostatic approximation, justification for this approximation, equation of quasi-hydrostatic motion using pressure as vertical co-ordinate.
3. Horizontal balanced motions, motion with no tangential acceleration, geostrophic and gradient wind relations, comparison of geostrophic and gradient wind, geostrophic thermal wind, streamlines and trajectories, barotropic and baroclinic atmosphere, thermodynamic energy equation, continuity equation, divergence of three dimensional and horizontal wind fields, vertical motion, vortices and circulation, Bjerknes' circulation theorem, introduction to stream friction and velocity potential, Rossby long waves, brief description of the baroclinic waves and baroclinic instability.
4. Angular momentum of the atmosphere about the earth's axis; relative and absolute momentum; balance of angular momentum; meridional transport by atmospheric disturbances; relation between this transport and zonal circulation; the balance of the atmosphere's kinetic energy internal energy; production, destruction and transport of energy; role of Baroclinicity; the energy circle of the general circulation; influence of oceans, continent and large scale orographic features on general circulation.
5. The nature of turbulent flow, flow near a boundary, the mixing length hypothesis; velocity profile near a boundary (smooth surface, rough surface); power-law profile; statistical theories of turbulence; eddy transport or momentum, heat and water vapour with planetary atmosphere boundary layer; the heat flux equation and the problem of convection; Richardson criteria; forced free convection.

## **THERMODYNAMICS**

1. Object of thermodynamics; thermodynamic system – definition, exchanges of energy and matter with the external world; closed and open systems; physical state of a system, variables of state, (p.v) systems, Clapeyron's diagram.
2. Temperature scales (Celsius, Fahrenheit, Kelvin); variables of state and the equation of state of a system; homogenous and non-homogenous system; thermal expansion of solids, liquids and gases – the laws of Boyle Mariotte, Gay Lussac, Avogadro and Dalton (gas mixtures); equation of state of a gas – perfect gas and van deer Waals' gas.
3. Definition of heat, quantity of heat, calorie, thermal conductivity, specific heat, case of gases, heat of change of phase, heat of reaction; calorimetric.
4. First law of thermodynamics; various forms of energy (work, heat, electricity, chemical, etc.); principle of conservation of energy; principle of the equivalency of heat and work (joule); internal energy, enthalpy; work accomplished by the expansion of an ideal fluid; reversible exchange of work and heat; adiabatic transformation, case of perfect gas.
5. Second law of thermodynamics.

## **DIFFERENTIAL EQUATIONS**

1. Differentiation and integration of simple functions, exponential functions, logarithmic functions and inverse trigonometric functions.
2. Partial derivatives; total differential and total derivatives.
3. Ordinary differential equations: equations of first order and degree; equation of higher degree; homogeneous and inhomogeneous equations.
4. Partial differential equations: linear partial differential equations of first and second order dent variables; the wave equation in one dimension; the vibrating string; normal modes of vibration and heat equation.

## **SYNOPTIC METEOROLOGY**

### **1. West African line squalls**

Definitions, formation, structure, propagation and maintenance. In-situ development, deep mesoscale convection systems. Importance to national economy.

### **2. Harmattan dust haze**

Definition, concept of plume, Mechanics of dust raising and transportation. Role of gravity in dust deposition, Clearance of dust haze, Frequency of dust spells. Behaviour of Saharan high pressure cell and mid- latitude trough, Dust particles as pollutants. Economic aspects in relation to human health, aviation and other sectors of the economy.

### **3. Monsoons**

Theory of global monsoon circulations. West African Monsoons-onset, maintenance, cessation and failure, Baroclinicity, energetics and vertical wind profile. Consequences of late onset and failure.

### **4. Little Dry Season (LDS)**

Definition, period of occurrence and area affected. Associated synoptic features, Aspects of divergence, vorticity and intensity. Critical temperature for onset and cessation.

### **5. Atmospheric general circulation**

One and three cellular models, Hadley and Ferrell cells, Establishment of wind and pressure systems globally. Energy exchange, creation of solenoidal fields. Application of Monsoons tilts at troughs and Redistribution of Meteorological quantities. Angular momentum balance.

### **6. African waves**

Origin and formation, structure, dynamics and stability criteria  
evolution of weather types.

7. Forcing function in West African  
Definition, concept of forcing functions. Influence of various forcing functions over West Africa. Location and structure of forcing functions e.g. African Easterly Jet (AEJ).
8. Frontal systems  
Mid-latitude and polar fronts. Cold front, warm front and occlusion. Association weather and synoptic features, Linkage with tropical systems. Dynamics of frontal systems.
9. Inter-tropical Discontinuity (ITD)  
Definition and characteristics. Dynamics, the three-dimensional structure, Association weather zones and concept of monsoon trough.
10. Wide-spread wet spells;  
Low level convergence and upper level divergence. Condition for sustained vertical motion. Circulation in vertical planes and solenoidal field.
11. West African Jets;  
African Easterly Jet – Location, existence period, structure, dynamics and influence on propagation storms. Tropical Easterly Jet – structure, dynamics, period of existence, location and influence on weather.

## **AERONAUTICAL METEOROLOGY**

1. General Aviation Services.  
Brief history of aviation and aeronautical meteorology. Operation aspects. Flight preparation. Flight plan. Meteorological service.
2. Hazardous Phenomena

Aircraft Icing: The formation of icing, elementary knowledge of icing types, accretion rates and association of icing with cloud (strati form and cumuliform clouds), freezing precipitation, orographic and frontal lifting.

Turbulence: Knowledge of turbulence near the ground as related to topography, air mass stability, clouds, front and thunderstorms. The hazards of aircraft turbulence. Sources of turbulent energy, convective turbulence, thunderstorm turbulence, mechanical turbulence Mountain wave turbulence. Characteristics of airflow over mountains, meteorological factors affecting mountain wave turbulence. High-level turbulence, forecasting high-level turbulence, turbulence associated with frontal and inversion surfaces.

Thunderstorms: Formation conditions, types of thunderstorm. The thunderstorm cell, aviation hazards, squall line thunderstorm hazards, hail hazards, hail formation, hail prediction and prevention lightning. Avoidance of thunderstorms.

Wind Shear: Low-level wind shear associated with marked inversion and/or low-level jet streams. Winds shear in the approach and landing phases of flight. Topographic winds shear.

Reduced surface visibility: Factors affecting visibility. Fog classification, air mass fogs, frontal fogs and fogs dispersal. Clouds and precipitation. Runway snow, slush and water various lithometeors: smoke, haze, dust, sandstorm and dust storm. Air pollutants.

Other hazardous phenomena: Volcanic ash at flight levels and international airways volcano watch (IAVW). Accidental release of radioactive materials hazardous to flight operation.

### 3. Meteorological service for International Air Navigation

Terminology. Area forecast centers. Aeronautical meteorological offices. Aeronautical meteorological stations. Observations made at Aeronautical meteorological stations. Meteorological reports from aeronautical meteorological stations. Aviation routine weather report (MET Report and METAR). Aviation selected special weather report (SPECIAL and

SPECI). Aerodrome forecasts. Forecasts for take-off. Landing forecasts (trend type).

Wind shear and Aerodrome warnings. GAMET area forecast, SIGMET and AIRMET (information). Route forecast. Dissemination of meteorological information. Information for and from air traffic services. Forms of meteorological messages. Information for search and rescue. Aeronautical climatological information.

Information for operations' local representatives. Information requires from operators. Information for pilots-in-command prior to departure. Information for pilots-in-command during flight. Debriefing.

Definitions should include:

Meteorological report, observation. Visibility, runway visual ranges. Altitude, elevation, height, aerodrome, flight-level transitional level. Aerodrome minima, instrument runway, landing forecast, aerodrome forecast, GAMET area forecast, SIGMET and AIRMET (information). Briefing route and special air-report, operator, operator's local representatives and pilot-in-command

#### 4. Operation of Aircraft

Flight planning: Definition, flight planning services, sources of meteorological information, available meteorological information, flight planning requirements and significance of meteorological information. Duties of flight operation officers when exercising operational control. Principles of flight. Air density and aircraft performance. Standard atmosphere. Density altitude other factors affecting aircraft performance. Fuel consumption. Radio meteorology. Effects of meteorological phenomena on ground communications. General flight navigation. Air pilotage. Electronic navigation. Celestial navigation. Aids to approach and landing. Flight planning aspects. Aerodrome meteorological minima.

#### 5. Aeronautical telecommunications

Understanding the general organization of aeronautical telecommunication; a thorough knowledge of the procedures applicable to the preparation of meteorological messages, which they or their assistants will normally originate. Operation of the Aeronautical Fixed Service including particularly the Aeronautical Fixed Telecommunication Network (AFTN), Aeronautical Telecommunication Network (ATN); message

headings, addressing of messages, priorities of messages, ICAO abbreviations used in messages; regional aeronautical MET telecommunication procedures (AMBEX, ROBEX); satellite distribution system for information relating to air navigation (SADIS) and international satellite communications system (ISCS). Other systems should include: Meteorological Data Distribution (MDD), RETIM (SYNERGIE-PC), SATCOM, Primary Data User System (PDUS), MESSIR-VISION, MESSIR-COM, the Global Telecommunication System (GTS) and all latest available systems or facilities.

#### 6. Air Traffic Services

Definitions. Flight rules. The nature of air traffic services. Air traffic control service. Area control service. Approach control service. Aerodrome control service. Responsibility for air traffic services. Demand for meteorological services, including the types of meteorological information required by the various air traffic services unit and the updating of this information.

#### 7. Organization for International Aviation Service

WMO Global Telecommunication system. Aeronautical telecommunication facilities. Meteorological telecommunication facilities. International coordination of procedures Regulatory documents and related publications.

#### 8. Meteorological aspects of flight planning

Meteorological basis for pressure-pattern flying, meteorological requirements for en-route winds and temperatures, weather and aerodrome forecasts. Significance of operational meteorological information (OPMET) in flight operations and planning. Interpretation of area, route and terminal forecasts preparation of material for briefing of flight crews. Use of flight documentation from the world Area Forecast System.

#### 9. WMO Documentation: Technical Regulations, (WMO-No.49), Vol.II – Meteorological service for International Air Navigation. Manual on codes (WMO-No.306). Guide on Meteorological Observation and Information Distribution System at Aerodrome (WMO-No.731). Guide to practices for Meteorological Offices Serving Aviation (WMO-No.732). Guide to

Meteorological instruments and Methods of observation (WMO-No.8).  
Weather Reporting (WMO-No.9).

10. ICAO Documentation: Annex 3 – Meteorological Services for International Air Navigation. Regional supplementary procedures\*\* (Doc. 7030). Procedures for Air Navigation services – ICAO Abbreviations and codes (PANS-ABC, Doc.8400). Location indicators (7010). Manual of Aeronautical Meteorological Practice (Doc. 8896). Manual on co-ordination between Air Traffic Services and Aeronautical Meteorological Services (Doc. 9377). Manual of Runway Visual Range Observing and Reporting Practices (Doc. 9328). ICAO/WMO manual on the provision of Meteorological Service for International Helicopter Operations (Doc. 9680). Relevant Air Navigation Plans (ANPs and FASID)\*\*.

## **CLIMATOLOGY**

1. General climatology, notion of climate, definition of climate physical factors of climate, importance of heat, radiation and humidity in climatology.
2. Astronomical and geographical factors: notion of solar climates; influence of latitude environmental influence on climate; effects of distribution of sea and land; degree of continentality; effects of water masses
3. Climatic elements: means climatic elements, classification, representation (mean, sum, frequency, normal, and variability), instruments and method of observation for various climatic elements.
4. Physical climatology: notion relating to the radiation, heat, energy and water balances, elementary notions on diffusion and turbulence; comparison of normal values and variability of climatic elements at the various latitude.
5. Dynamical climatology: general atmospheric circulation; centers of activity and types of climate associated with them; climatologically aspects of dynamical meteorology; representation of climatologically data.

6. Synoptic climatology: grouping of climatic elements according to the nature of the air masses; mean or frequency of climatic elements associated with types of weather; geographical distribution of fronts; frontal zones and air masses and climatological phenomenon associated with them.
7. Regional meteorology: description of the climate of the globe; climatology of the region or country where the training is given qualitative description, numerical data, maps and atlases.
8. Meso and microclimatology: general principles, concepts and definitions; examples of microclimates.
9. Bioclimatology: general principles, concepts and definitions; bioclimatology related to the various human activities and associated fields.
10. Applied climatology: general notions on the application of climatology to the various human activities (agriculture, aeronautics, marine, public work, transport, etc.), Climatic changes: basic notions
11. Special climatological methods: climatological statistics: emphasis is on the practical aspects.
12. Machine processing of climatological data: punched cards, magnets tapes, punched tapes; use of computer: programming (principles and simple application).

## **HYDROLOGY**

1. Hydrology, Hydrometeorology; Definitions and Explanations  
Water bodies of the world, Role of water in Economic Activities of Nations:
2. Physical: properties of water cycle on the globe: physical properties of Water; the hydrological cycle on the earth; ground water; origin and Classification of ground water; physical properties of rocks in lationship to water; physical states and movement of ground water; ground water

and its relationship to rivers; confined aquifer ground water and its role in the river feeding; Lakes and reservoirs; morphology of lakes; sources of inflow to lakes; water balance of lakes; dynamic phenomena on lakes (waves and currents).

3. Heat regime of lakes; chemical composition of lake water; biological processes in Lakes; reservoirs, their regime and water balance; swamps; formation and classification of swamps; hydrological regime of swamps; hydrological regime of swamps; formation and movement of glaciers, their influence on river inflow and regime.
4. River system; river basins; river valleys and channels; sources of river Flow; temperature regime of rivers; regime of river stages; movement of water in rivers; flow velocity; discharge in rivers, hydrograph analysis; sediment transport; chemical composition of river water; channel formation processes; water balance and runoff; units used to measure runoff and flow; water balance and runoff units used to measure run off and flow; water balance of bodies of water.
5. Calculation of evaporation from the surface of basin; Average long-term annual runoff: distribution of annual runoff in Months and seasons; flow duration curves, mass diagrams and Storage Behaviour diagrams; maximum discharge and its calculation; Minimum flow and its calculation; sediment discharge and its calculation.
6. General alter Balance equation
7. Hydrograph Analysis  
Knowledge of flood regime of a stream, intelligent design of a wide Variety of hydraulic structures such as bridges and culvert openings, Reservoir spillways and flood control works of all sort.
8. Ground Water (GW).

## **VECTOR ANALYSIS – VECTOR ALGEBRA AND VECTOR CALCULUS**

1. Introduction-definition and examples of scalar and vector quantities, Representation of a vector; vector fields, scalar fields.
2. Vector Algebra – addition, subtraction and multiplication of vectors, the null Vector, magnitude of a vector; unit vector; law of vector algebra.
3. Components of vectors – vectors in two and three dimensions, etc.
4. Cartesian system of reference direction in two and three dimensions-

Magnitude of a vector in the Cartesian system.

5. Direction Cosines – definition of, angles between two angles in Cartesian components; etc.
6. Relative vectors – position vectors, velocity acceleration vectors, Division of a line in a given ratio, co linearity of points
7. Scalar or dot product of two vectors, properties of the scalar product; special cases of the scalar product, work and scalar product
8. Vector or cross product of vectors, properties of the vector product, Applications of the vector product, Cartesian form
9. Vector equation of a straight line, position vector of a point on a circle
10. Scalar triple products and vector triple products
11. Derivative of a vector function – definition, space curve, partial derivative of Vectors, velocity vector, application of vector in mechanics
12. Gradient field, Divergence of a vector and Curl of a vector – the vector Differential operator Del, the gradient, the divergence, the curl; some Formulae involving Del
13. Application of vectors to geometry;
14. Vector identities (reciprocal set of vectors);
15. Vector Integration.

## **SATELLITE METEOROLOGY**

1. Basics in remote sensing  
Physics behind remote-sensing
2. Introduction  
History of meteorology satellites
3. Satellites-data acquisition, processing and archiving  
Satellite orbits, characteristics and radiometers  
Satellite data acquisition, processing and data management.
4. Satellite image analysis and interpretation  
Satellite image analysis, display and interpretation

Application of satellite imagery both in the visible and infrared  
Regions for the analysis and interpretation of weather systems.

5. Case-studies, that is, a series of practical examples to examine a range of Meteorological events over the African continent, tropics and mid-latitude  
With emphasis in the application of satellite Meteorology to  
Public weather forecast  
Aeronautical Meteorology and  
Agro-meteorology.

## 6.0 Future satellites

### **AGROMETEOROLOGY**

1. Introduction, Definition, aims, Scope, Objective and relationship of agricultural meteorology to other allied subjects.
2. The relationship between weather and agriculture, soil, plants, farm animals (Livestock); diseases and pest of crops and animals, farm building and equipment. Artificial modification of meteorological and hydrological regimes.
3. The history of Agriculture and its relationship with association science. The relationship between Agriculture and weather elements. Agricultural Ecology and Ecosystem Distribution and Classification of Vegetation belts in Nigeria. Weather and climatic modification for
4. General production practice of field crops, crop production e.g. Maize  
Production factors for optimum yield of field crops.  
Factors affecting crop yield; Environmental factors – rainfall, CO<sub>2</sub>, temperature, radiation, wind, light, evaporation water supply, nutrient, weed, pest and disease soil physical condition. Plant population, field of individual plant and community
5. Plant protection – Introduction- pest: definition of pest, important of pest. Important of plant protection.  
Types of Pests: Polyphagous pest, Locusts, Termites, Bihar hairy Caterpillar, Cutworm, Greasy Cutworm, Damage caused by locust phase  
Theory of locust life cycle of locusts and control.
6. Phenology  
Definition of phenology  
Method of phenological observations. Different phases of phenological Observation in different crop plants.
7. Agrometeorological elements and their methods of observations.  
Definition, climatic elements, Biological elements, conditions of

observation, Agrometeorological station and Networks, Observation of physical elements, Observation of biological Character/Elements, Detail observation of high accuracy.

8. Climatic normal for livestock's: poultry birds, Goat, Sheep, Pigs and Cattle. Meteorological equipment of crop plants for rice, sugar cane, cotton, maize, potatoes etc. Animal's production systems, uses of animals. Outdoor animals and Meteorological elements.
9. Water and the Hydrological Cycle in Agriculture moisture characteristics of soil water and vegetation. Determination of water loss from land surface fundamental of the evaporation process. Existing methods of determining evaporation Energy balance of estimating evaporation Aerodynamic estimation of evaporation combination model methods of penman and others. Development of original penman equation. Evaporation formulae of priestle – Taylor and Penman – Monteith special forms of precipitation Dew, Snow, soil moisture Budgets – Irrigation needs

## **PHYSICAL METEOROLOGY**

1. The sun, earth and electromagnetic radiation. Features of the Sun, motions of the Earth; seasons; duration and intensity of sunshine ; solar radiation; types of heat transfer radiant energy and light; blackbody radiation; emissivity, absorptivity and transmissivity. Qualitative discussion of radiation laws Kirchhoff, Plank, Stefan-Boltzman, Wien; scattering; absorption of the radiant energy in the atmosphere; albedo of natural surfaces; upper surface of clouds, land surfaces, water greenhouse effect. The heat balance of the atmosphere; terrestrial radiation; the free atmosphere radiation; radiation flux; the earth heat balance.
2. Introductory atmospheric thermodynamics. Vertical structure of the atmosphere; Distribution of temperature and pressure; troposphere; stratosphere; tropopause; upper atmosphere; adiabatic process hydrostatics balance; geopotential; The lapse rate; vertical stability.
3. Atmospheric moisture; condensation process. Water vapour; change of phase; vapour pressure; saturation; absolute and specific humidity; relative humidity; temperature of dew point. Change of phase; adiabatic process at saturation; reversible adiabatic and pseudo adiabatic condensation process; formation of clouds and precipitation; wet-bulb temperature; thermodynamics diagrams; tephigram; conditional and convective instability.
4. Atmospheric motion; geostrophic flow. Atmospheric pressure; gravity; pressure gradient force; hydrostatic balance; Coriolis forces; geostrophic wind; variation of wind and temperature with height; upper winds; frictional force. Orographic effects; local winds; convection; elements of atmospheric turbulence.

5. Element of atmospheric optics and electricity. Atmospheric refraction, rainbow, halo, corona, blue of the sky; transparency of the atmosphere and visibility; air conductivity, lightning discharge and thunderstorms.
6. Energy balance of the upper atmosphere; photo ionization; photo dissociation of oxygen; ozone layer.
7. Cloud and precipitation; water cycle Evaporation; condensation and sublimation; saturation vapour pressures over liquid and solid; relative and specific humidity; suspended particles. Formation of fogs, mist and cloud; cloud condensation nuclei. Growth of a drop by condensation cloud droplets growth by collision and coalescence.

## **SYNOPTIC METEOROLOGICAL PRACTICALS**

1. Definition of Analysis  
Composition/Design of various Charts
2. Types of elements and the charts used  
Rules governing Analysis/Nature of Analysis  
Types of Analysis and available  
    Surface  
    Upper Air  
    Frontal
3. Importance of the above to science of Meteorology
4. Practical Exercise  
  
The use of PDUS, AFDOS, Messivision and Radar in Meteorology and Global Model Charts
5. Synoptic Systems Theory  
Dust Haze, Fog, Thunderstorms/Line Squall

## **STATISTICS**

1. Graphical representation of data; finding the mean, median and mode of grouped data; Quartiles, percentiles, deciles etc.
2. Regression and Correlation  
Scatter graphs, Relationships between two variables and scatter graphs (construction, line of best fit, and estimate from scatter graphs significance of the scatter graph, limitations of scatter graph) computing regression lines equation; method of least squares, measuring the deviation; the regression of y on x; graphing regression lines; the use of regression lines; choice of regression line and regression coefficient.

Correlation (computation of  $r$ ; interpretation of  $r$ ; types of correlation; Rank correlation  $r^1$ ; the equation of a least square line and fitting the data; Multiple linear regression and non-linear regression.

3. Probability

Conditional probability; independent and dependent events; mutually exclusive events; Mathematical expectation; permutations and combinations. Probability distributions, the binomial distribution, the Poisson distribution, Properties of the Normal distribution. The relation between binomial and normal distribution.

4. Estimation

Tests of significance; testing a hypothesis; the null hypothesis, testing the null hypothesis, rejecting of the null hypothesis, non-rejection of the null hypothesis, confidence level.

5. Venn diagrams.