**DEPARTMENT OF PHYSICS AND ASTRONOMY POST-GRADUATE PROGRAMME CURRICULUM FOR MASTERS DEGREE (M.Sc)**

**Department Information**

The Department of Physics and Astronomy offers the following postgraduate degree programmes

Courses are offered in the following areas;

1. Condensed Matter Physics
2. Medical Physics
3. Theoretical High Energy Physics
4. Solid Earth Geophysics
5. Astrophysics
6. Atmospheric Physics
7. Solar Energy Physics / Materials Science

**Philosophy**

Physics is a fundamental science that exposes people to the basic laws of nature and the principles required to understanding these basic natural laws. Astronomy on the other hand introduces the students to the natural laws and principles of heavenly bodies that include the planets, galaxies and stars. It is therefore envisaged that students graduating from the department will have received sufficient training in various aspects of physics to enable them appreciate and interpret natural/physical phenomena from a scientific point of view.

**Objectives**

The aim of the post graduate (PG) programme in the Department of Physics is to impart sound knowledge in key areas of research and ultimately lead to the production of high level man power in these areas of Physics. The graduates from our PG programme are expected to develop a high degree of competence in thinking independently about research problems and seeking to provide insight into solutions using the techniques’ learned as physicists.

**Job Opportunities**

Successful graduates of the above degree programmes are well equipped for postgraduate studies and teaching in the relevant subject. Their training also prepares them for careers in Government Departments, e. g. Meteorology, Geological Survey, National Standard organization; in Industrial research Establishment e.g. Astronomical Observations NRAO, NAOJ, ESO, ALMA, FIIRO, PRODA, NASDRA, NASENI, NAEA, SHETSCO; In oil, steel and other industries; and commercial and technical firms needs the services of a physicist.

**ENTRY REQUIREMENTS**

**MSc. Degree Programme**

**Basic Admission Requirements**

The criteria for admission into the Master’s programme (MSc.) will be as follows:

(a) All candidates must have five credit passes including English, Mathematics, Physics and two relevant subjects at ‘O’ Level.

(b) Candidates with Bachelor’s degrees in Physics from an approved university must obtain a minimum of second Class lower division with a CGPA of 2.5/5.0 for an academic programme.

**Expected Duration of Programme**

1. A fulltime Academic Masters programme should run for a minimum of 3 semesters and a maximum of 6 semesters
2. Part-time Academic Master’s programme should run for a minimum of 4 semesters and a maximum of 8 semesters.
3. For extension beyond the specified maximum period, a special permission of senate shall be required.

**Requirements of Graduation**

To be awarded a Master’s degree candidate must pass a minimum of 30 units courses made up as follow:

* Minimum core courses of 2units, including the general courses, research project and seminars
* Elective courses of minimum of 8 units
* A student shall present at least one seminar, submit and defend a research project
* A student for an Academic Master’s degree programme shall carry out research in a relevant area of specialization and submit an acceptable research project (6 units) which must be defended before a panel of external and internal examiners.

**STRESS AREAS**

General/Core courses 0

Condensed Matter Physics 1

Medical Physics 2

Theoretical High Energy Physics 3

Solid Earth Geophysics 4

Astronomy 5

Atmospheric Physics 6

Solar Energy Physics/ Materials Science 7

Research project / Seminar 9

**COURSES TO BE OFFERED FOR M.Sc PROGRAMME**

**GENERAL/CORE COURSES**

**FIRST SEMESTER**

**Course No**.

**CREDITUNITS**

PGC 601 Research Methodology and Application of ICT in Research 3

PHY 603 Quantum Mechanics 2

PHY 605 Statistical Physics 2

PHY 607 Methods of Theoretical Physics 2

A minimum of 2 courses from candidate special area 4\_

**13**

**SECOND SEMESTER**

**Course No.**

PHY 602 Classical Electrodynamics 2

PHY 604 Computational Analysis in Physics 2

PHY 692 Seminar/Workshop 3

PHY694 MSc. Project 6

A minimum of 2 courses from candidate special area 4\_

**17**

**COURSES IN AREAS OF SPECIALIZATION**

For a student to be credited with specialization in any these areas, he/she must register for additional courses of 8 credits minimum(for the entire programme) from the following courses in the various fields of specialization.

**1. CONDENSED MATTER PHYSICS**

PHY 610 Crystal Symmetry Groups and Lattice Dynamics 2

PHY 611 Electronic Energy Band 2

PHY612 Electron-Electron and Electron Phonon Interaction 2

PHY 613 Condensed Matter Physics and application 2

PHY 614 Magnetism and Superconductivity 2

PHY 615 Experimental Study of Materials 2

PHY 616 Experimental Techniques for Low and High

Temperature and for Low and High Pressure 2

PHY 617 Experimental and Solid State Physics 2

**2. MEDICAL PHYSICS**

PHY 620 Fundamentals of Nuclear Physics 2

PHY 621 Radiation Detection and Dosimetry 2

PHY 622 Nuclear Application in Medicine, Industry and Research 2

PHY 623 Non-Ionizing Radiation 2

PHY 624 Physiology and Anatomy 2

PHY 625 Radiation Protection 2

PHY 626 Radiobiology 2

PHY 627 Physics of Diagnostic Radiology 2

PHY 628 Physics of Therapeutic Radiology 2

PHY 629 Medical Instrumentation 2

**3. THEORITICAL HIGH ENERGY PHYSICS**

PHY630 Group Theory and its application to Physics 2

PHY631 Invariance Principle in Physics 2

PHY632 Gauge Field Theories 2

PHY633 Unified Theories 2

PHY634 Phenomenology 2

PHY635 Supersymmetry and Supergravity 2

PHY636 Selected Topics on Recent Developments in Element Particle Physics 2

**4. SOLID EARTH GEOPHYSICS COURSES**

PHY 640 Physics of the Earth’s Interior 2

PHY 641 Seismology 2

PHY 642 Gravity and Magnetic Methods in Geophysics 2

PHY 643 Electrical Methods in Geophysics 2

**5. ASTROPHYSICS**

PHY 650 High Energy Astrophysics 2

PHY 651 General Relativity 2

PHY 652 Cosmology 2

PHY 653 Observational Astronomy 2

PHY 654 Galactic and Extragalactic Radio Astronomy 2

PHY 655 Random Signals and Noise Processing 2

PHY 656 Radioastronomy and Space Science Instrumentation 2

PHY 657 Plasma Physics 2

**6. ATMOSPHERIC PHYSICS**

PHY 660 Meteorology 2

PHY 661 Physics of the Geomagnetic Phenomena 2

PHY 662 Aeronomy 2

PHY 663 Radio Propagation 2

PHY 664 Physics of Remote Sensing 2

PHY 665 Communication and Satellite Technology 2

**7. SOLAR ENERGY PHYSICS / MATERIALS SCIENCE**

PHY 670 Solar Energy Availability and Collection 2

PHY 671 Solar Energy Conversions and Storage 2

PHY 672 Synthesis of Nanomaterials and Nanostructures for Solar Energy Applications 2

PHY 673 Characterization Methods for Nanomaterials and Nanostructures 2

PHY 674 Semiconductor Physics 2

PHY 675 Experimental Study of Solar Energy I 2

**COURSE DESCRIPTION**

**PGC 601 Research Methodology and Application of ICT in Research**

In-depth research work aimed at acquiring full knowledge and presentation in scholarly writing of the concepts, issues, trends in the definition and development of the study area from African and Western perpectives. Major steps in research : Selection of problem, Literature review, Design, Data collection, analysis and interpretation, conclusions. Study of various research designs, Historical, Case studies, Surveys, Experimental, etc Analysis, Surveys and synthesis of conceptual and philosophical foundationDescriptive, Cross sectional, foundations of different disciplines. Identification of research problems and philosophical foundations of diffent disciplines, Identification of research problems and development of research questionsand or hypotheses. Detailed treament of methods of collecting relevant research data and the format for presenting research results (from designing the table of contents to referencing, bililiography and appendix). Data analysis and result presentation in diffent discipllines using appropriate analytical tools. Methods of project/dissertation writing. Application of appropriate advanced ICT tools relevant in every discipline for data gathering, analysis and result presentation. Essentials of Spreadsheets, Internet Technology, and Internet search engines. All registered Masters degree students must attend a solution based interactive workshop to be organised by the School of Postgraduate studies for a practical demonstration and application of the knowlege acquired from the course, conducted by selected experts.

*(3 units*)

**PHY 602 Classical Electrodynamics**

Maxwell’s equation-covariance under Lorentz transformation, four potential, field tensor, Lorentz gauge. Motion of charged particles in electromagnetic field. Fields due to a system of charges – retarded potential, Multiple expansion of electromagnetic field. Radiation from accelerated charges- problem of radiation reaction and self energy.

*(2 units*)

**PHY 603 Quantum Mechanics**

Fundamental principles of quantum mechanics. Schrodinger, Heisenberg and interaction pictures. Operators, state vectors representations, Dirac notations. Elements of scattering theory. Born approximation; time-dependent perturbation theory. Green’s function method, partial wave expansion. Application to the H-atom and laser. Theory of angular momentum-addition of angular momentum.

*(2 units*)

**PHY 604 Computational Analysis in Physics**

Introduction to UNIX (dif, awk, gedit, vi) MATLAB array operations 2-D and 3-D Plots with Matlab calculus & transforms with matlab FORTRAN programming. Phython scripting and applications in physical problems, C & C+ + programming latex.

*(2 units*)

**PHY 605 Statistical Physics**

Liouville theorem. Microcanonical ensemble. Canonical and grand canonical ensembles. Fluctuations. Darwin-Fowler method, classical limits of statistical mechanics Equipartition theorem. Black body radiation. Debye theory of specific heat. Foundation of statistical mechanics. Ideal classical, Bose and Fermi gases. Imperfect gas. Cluster expansion. Phase transition. The Isino Model. Molecular field approximation. Critical fluctuation. Time correlation function. Fluctuation-dissipation theorem.

*(2 units*)

**PHY 607 Methods of Theoretical Physics**

Uses of Fourier series. Fourier and Laplace transforms in physics. Uses of complex variable and analytical continuation. Solutions of second order ordinary and partial differential equations. Mathieu, Bassel, Legendre equations etc. Greens function. Integral equations and Feynman’s diagrammatic techniques. Theory of matrices. Numerical methods. Eigen value problems. Transformations and elements of group theory and applications.

*(2 units*)

A student admitted into Master’s degree programme must register for a minimum of 30 units and a maximum of 40 units per session on the advice of his/her supervisor.

1. **ELECTIVE COURSES FOR CONDENSED MATTER PHYSICS**

**PHY 610 Crystal Symmetry Groups and Lattics Dynamics**

Symmetry of crystals, quasicrystals and nano-crystals, point groups, representations, and character tables,. The Reciprocal Lattics and Brillion Zone Scheme. Atomic Scattering factor and geometrical Structure Factor. Debye-Waller Factor in Solids. Meltings, Interatomic Forces in Solids, and cohesive energy. Lattics Dynmics in the Harmonic approximation. Dispersion relation. Phonon density of states. Heat capacity of Solids. Thermal expansion and Thermal conductivity of solid. Neutron Scattering.

*(2 units*)

**PHY 611 Electronic Energy Band**

The free electron model, Electrons in periodic potential Bloch’s theorem. Brillouin Zone. Boundary Effects, Fermisurface, Metals, semiconductors and Insulatos, Quasi-and nano-crystals. Density of States. Femi- dirac Statistics and Electronic Heat capacity. Effective mass theory. Ralativitistic energy bands and spinobit effects, Methods of energy bands structure calculations – plane wave method, tight-binding method, orthogonalized plane wave method. Green’s function method.Wannier representation.

*(2 units*)

**PHY 612 Electronic – Electron and Electro-Phonon Interaction**

The free electron approximation. Hartree and Hartree-Fock equations for many-electron systems. The Pauli exclusion principle. Exchange and correlations. Screening and Dielectric function of the electron gas. Many-body perturbation and Feynman diagrammatic techniques for interacting electron gas Self-energy and renormalization effects. Landau’s Fermi liquid theory. Quasi-particles, elementary excitations in solids: excitations polatons. Magnons etc. The Hubbard Hamiltonian model. The adiabatic principle of Born-Oppenheimer approximation and separation of electronic and ionic motions in metals. Non-adiabatic terms and electron-phonon interaction. Representation of electron-phonon interaction by pseudopotentials Screening of matrix elements. Application to phonon spectrum calculations, transport properties etc. *(2units)*

**PHY 613 Condensed Matter Physics and Applications**

Review of Semiconductor physics – Crystal structures energy bands, simple models and properties of electron and holes Impurities, binary alleys, n-type and p-types doping, semi-conductor devices – p-n junction, photovoltaic cells, semi-conductor lasers. Integrated circuits, large scale integration. Alloys, phase Diagrams, Steel etc. Non-ferrous materials, glasses, plastics etc.

*(2 units)*

**PHY 614 Magnetism And Superconductivity**

The electron spin. Para-, ferro- and anti-ferromagnetism. Magnetic properties of insulators and metals. The Ising Model and Heisenberg Hamiltonian Superxchange in antiferromagnets. Magnetism of dilute alloys Konde effect Phenomenological model of Superconductivity. Electron pairing BCS theory Ordinary and Heavy Fermion superconductors. Properties of super-conductors. Meter Insulator transitions and co-existence of magnetism and superconductivity. High-TC superconductors. Applied superconductivity.

*(2 units)*

**Phy 615 Experimental Study of Materials**

Preparation and study of material used in industry. X-ray, electron and neutron scattering from materials. Electron microscopy.

*(2 units)*

**PHY 616 Experimental Techniques for Low and High Temperatures and for**

**Low and High Pressure**

Production of low temperatures-liquefaction of gases, adiabatic and nuclear demagnetization. Low temperature thermometry. Heat transfer Storage of liquid air (nitrogen) and helium. Production and measure of high temperatures; induction, arc and differential furnaces. Vacuum techniques-production and measurement of low pressures. Rotary molecular diffusion and ion-diffusion vacuum pumps. High pressure technique – design and construction of pressure pumps. Application of high pressure in deep-sea and alloys under high pressure and high temperatures.

*(2 units)*

**PHY 617 Experiment Solid State Physics**

Selected experiments in Solid State Physics and Materials Sciences.

*(2 units)*

**B. ELECTIVE COURSES FOR MEDICAL PHYSICS**

**PHY 620 Fundamentals of Nuclear Physics**

Introduction and basic concept: Definition, nuclear properties, nuclear potential and energy levels. Radioactivity and transformation kinematics. Nuclear collision. Nuclear instability and decay, Electron capture (EC), decay and semi classical theory of decay, gamma decay and yield selection rules. Internal conversion (IC), Auger electron (AET). Mechanics and energy transfer of heavy changed particles (Bethe-Bloch formula Bragg curve, energy requirements etc), fast electrons, gamma-rays, neutrons including attenuation and moderation. Nuclear reactions: general features of nuclear reactions, elastic scattering, direct reaction, compound nucleus reaction, Heavy ions reaction. Brief review of concepts and principles of reactors and criticality.

*(2 units)*

**PHY 621 Radiation Detection and Dosimetry**

Radiation quantities: Definition and Units Radiation detection methods: Ionization in gases, Ionization in semiconductors. Scintillation Gamma Spectrometry, Neutron detection, Thermoluminescence, Film Dosimeter, Chemical Dosimeter (Fricke). Particle tract detection, calorimetry, etc. Counting statistics. Dosimetry: External Dosimetry (Gamma mammography, fluoroscopy and computed tomography).

*(2 units)*

**PHY 622 Nuclear Application in Medicine, Industry and Research**

Physics and principles of diagnostic imaging equipments. Radiography unit, computed tomography unit, mammographic units. Principles of radiation therapy (teletherapy and brachytherapy). Principles of radiotherapy equipment; CO-60 Unit and Linear accelerator. Physics and operational principles of Gamma camera. Physics of Position Emission Tomography (PET). Physics and operational principles of Magnetic Resonance Imaging (MRI). Industrial Uses: Industrial radiography, Tracing, Guaging. Material Modification. Sterilization food preservation and others. Research Uses. Neutron Activation Analysis. Particle-Induced N-ray Emission PIXE and others.

*(2 units)*

**PHY 623 Non-Ionizing Radiation**

Radiometric Units Lasers: Laser operations. TEM modes, Biological effects: eye damage, skin damage protection guides and standards, Maximum Permissible Exposure (MPE). Safety Measurement, Power and Energy. Beam divergence radiofrequency (RF) and Mocrowave: Communications, antennas and gain: G. penetration depth, GSM land-sets and base stations. Biological Effects. Thermal and non thermal effects, temperature-humidity index microwave measurements, survey meters. Protection guides and standard maximum permissible exposure (MPE safety)

*(2 units)*

**PHY 624 Physiology and Anatomy**

Anatomical nomenclature: Cells, tissues and organs. Anatomical landmarks, joint articulations, limb movements, muscles, brain, spinal cord and peripheral and autonomic nervous systems; Anatomy of the various systems of the body. Homeostasis. Blood and body fluids: circulation, respiration, digestion, renal physiology. Recticulo-endothelial system: Neural physiology; Reproduction and Respiratory physiology; Pathology.

(*2 units)*

**PHY 625 Radiation Protection**

Intriduction and historical perspective; Principles of radiation protection; Orders of risk. Maximum permissible dose levels shielding calculations. Occupational exposure; exposure of members of the public legislation; Stochastic and non-stochastic effects; Methods of dose optimization; Investigation levels; Maximum permissible level (MPL). Annual limit of intake (ALI) and derived working level (DWL). Calculation of protective barriers; Non-ionizing radiations protection; Radiation Detectors in radioprotection; Radiation protection in diagnostic radiology; Radiotherapy and nuclear medicine; Design and construction of radiation safes; Technical control of hazards including: Shielding; Personnel and environmental radiation monitoring; Contamination and Decoontamination; Leak testing; Waste management; Transport and management of radiation sources; Accident and emergency; Quality control (QC) and Quality Assurance (QA) in medical and industrial applications; Legislation; Professional Ethics.

*(2 units)*

**PHY 626 Radiobiology**

Review of interaction of radiation with matter; Biological end-points; Sub-cellular, cellular and molecular radiobiology: Survival Curves in vivo, mixed, D0DL50; Radiation injury; Radiation damage, injury and repair; Radiation-indirect chromosome; Damage and repair; Survival Curve Theory; Cell Death; Cellular Recovery Processes; Cell Cycle; Modifiers of Radiation response – sensitizers and protectors; Radiation quality; RBE, OER and LET; Cell Kinetics; Radiation injury and Tissues: Radiation Pathology – Acute and Late Effects; Histopathology; Tumor Radiobiology; Time, Dose and Fractionation; Radiation Genetics: Radiation effects of Fertility and Mutagenesis: Molecular Mechanisms; Drug radiation interaction (Chemical Modifier)

*(2 units)*

**PHY 627 Physics of Diagnostic Radiology**

X-ray production and diagnostic radiology. Basic radiation interaction processed in relation to radiodiagnosis. Physical principles of medical radiography radiographic image quality; Fluoroscopy, Computerized tomography-image formation and quality; Digital imaging system and image processing; Specialized Digital Techniques. Medical radionuclides: Classification; production and clinical application techniques. Preparation of labeled compounds, and pharmaceuticals. Principles of tracer kinetics and dynamic studies. Quality assurance and control in radiodiagnosis and nuclear medicine procedures. Radiation protection for staff and patients.

*(2 units)*

**PHY 628 Physics of Therapeutic Radiology**

Physical principles of radiotherapy. Clinical applications of radiation dosimetry in treatment planning; Clinical photon and electron Beams; Depth Dose distribution: Radiation measurements; Calibration of radiation therapy equipment; Special external beam radiotherapy techniques; Quality assurance and control; Branchytherapy; Teletherapy dosage data for clinical use. Megavoltage and kilovoltage radiations. Implant techniques and calculations. Internal use of radionuclides for therapy. Radiation protection for patients and staff; Target volume definition and dose prescription criteria (ICRU 50 and ICRLJ 62); Clinical Photon Beams: Dose, Modelling and Treatment Planning; Intensity-modulated radiotherapy (MRT)

*(2 units)*

**PHY 629 Medical Instrumentation**

A basic theoretical and experimental course looking at aspects of devices; system electronics and medical instrumentation; Recording systems: Magnetic, Photographic etc. Display of physiological signals (EEG, ECG, EMG, UCG); Tomography; Interfacing of measuring systems to computers; Noise and interference in hospital environ.

*(2 units)*

**C. ELECTIVE COURSES FOR THEORETICAL HIGH ENERGY PHYSICS**

**PHY 630 Group Theory and its Application to Physics**

Finite and infinite groups, continuous groups, Classical group, Symmetric groups. Lie algebras classifications – simple and semi simple Lie algebras, Lie-isotopic and Lie-admissible algebras. Representation of groups – matrix representations. Unitary groups – SU(2) SU(3), SU (4) and SU (5) and their Lie-isotopic generalizations. Their relevance to physics.

*(2 units)*

**PHY 631 Invariance Principle in Physics**

Space time transformation – rotation and Lorentz groups, Poincare transformations and generalizations unitary representations of the Poincare-invariant amplitude heliocity state, spinor amplitudes. Discrete symmetrics-space inversions, time reversal, charge conjugation, CPT theorem. Invariance principles in field theories. Noether’s theorem, conserved and partially conserved current gauge transformations: Global and local.

*(2 units)*

**PHY 632 Gauge Field Theories**

Elements of quantum electrodynamics – perturbation Feyman diagrams. Renormalization programme – pauli-Villars and dimensional regularization BPHZ prescription. Non-Abelian gauge theories –path integral methods, OPI vertices, Schwinger-Dyson equation. Renormalization group equation.

*(2 units)*

**PHY 633 Unified Theories**

Introduction to classical weak interaction theories current algebras. PCAC. Salam- Weinberg theory of electroweak interactions. Renormalizability of the spontaneously broken theories, Grand unified theories.

*(2 units)*

**PHY 634 Phenomenology**

Kinematics, S=Matrix properties of scattering amplitudes, crossing symmetry, dispersion relations, Regge Poles, duality. Deep inelastic scatting parton model, quarks, gluons, operator product expansion. Perturbative QCD, jets and their phenomenology.

*(2 units)*

**PHY 635 Supersymmetry and Supergravity**

Glassman variables, superspace and global supersymmetry representation superfields. Field theories in superspace superfield methods. Extended supersymmetries, Supergravity. Supersymmentric grand unified theories.

*(2 units)*

**PHY 636 Selected Topics on Recent Developments in Elementary Particle Physics**

String Theory, Hadronic Mechanics, etc

*(2 units)*

**D. ELECTIVE COURSES FOR SOLID EARTH GEOPHYSICS**

**PHY 640 Physics of the Earth’s Interior**

The origin and broad structure of the earth. Radiometric age dating. Rotation of the earth. Composition of the crust, mantle and core. The earth’s core and the magnetic field. Terrestrial heat flow. Ocean ridges. Mountain ranges and rift valley. Continental drift by sea floor spreading. Fracture and flow in the crust and mantle. The origin of the earth’s surface features. Continental drift and paleomagnetism. Earthquakes and plate tectonics plate boundaries and kinematics

*(2 units)*

**PHY 641 Seismology**

Principle of refraction and reflection prospecting including modern techniques and application. Introduction to the theory of seismic wave propagation. Plane wave theory of body and surface wave. Theory of seismometers. Modern seismic recording equipment and field techniques Modern seismic processing and interpretation techniques with special application to prospecting and earthquake seismology. Introduction to earthquake seismology. Earthquake location. Inversion of seismic body wave data. Seismicity and Earthquake mechanisms.

*(2 units)*

**PHY 642 Gravity and Magnetic Methods in Geophysics**

Gravity and magnetic potential Derivation of field from potential. Poisson’s relationship between gravity and magnetic potentials. Gauss’s and Green’s theorems. Laplace’s equation. Upward and downward continuation. Spherical harmonics. The shape of the earth. Clairau’s theorem. Gravity field measurements on land, at sea and in the air. Interpretation of gravity anomalies, Magnetic methods: The geomagnetic field and its measurements on land, at sea and in the air; field procedure for land for land, sea and air operations. Interpretation of magnetic anomalies.

*(2 units)*

**PHY 643 Electrical Methods in Geophysics**

Electrical properties of rocks. Methods employing natural electrical sources; self potential method, telluric and magneto-telluric methods. Electromagnetic methods: Electromagnetic theory, combination of electromagnetic field system for ground surveys, air borne electromagnetic systems, procedure for electromagnetic surveys, interpretation, field examples. Geophysical well logging: electrical methods, radioactivity method, elastic wave propagation methods, gravity magnetic and thermal methods, well log: interpretation.

*(2 units)*

**E. ELECTIVE COURSES FOR ASTROPHYSICS**

**PHY 650 High Energy Astrophysics**

Radiation processes – thermal, synchrotron, bremstrahlung, inverse Compton and coherent. Equation of state and physical processes at high densities and high temperatures and application to final stages of stellar evolution-(While dwarfs, supermovae, neutron-stars, pulsars, black holes), and to sources of high- energy radiation- (x-ray, gamma-ray cosmic ray gravitational wave sources).

*(2 units)*

**PHY 651 General Relativity**

The principles of equivalence, gravitational force, the equation of motion, the affine connection, the metric tensor. Tensor analysis. Effects of Gravitation. Curvature. Einstein’s field equations: derivation of the field equations. Applications of General Relativity: Class tests of Einstein’s theory, the gravitational field in empty space, the Schwarzchild metric, advance of perihelion, gravitational radiation, the schwarzschild’s singularity and gravitational collapse.

*(2 units)*

**PHY 652 Cosmology**

Observational background: structure and mass density of the Universe, radical motion of the galaxies, Olber’s paradox, microwave background. General theoretical concepts –the cosmological principle and basic concepts of time, distance, rotation, inertia, etc. Newtonian cosmology, special and general relativity, relativistic cosmology. Inflation, cosmic defects and strings. Other cosmological theories. Dark matter – Observable properties of World models and cosmological tests.

*(2 units)*

**PHY 653 Observational Astronomy**

Spherical Astronomy Optical/astronomy, bands and features. Observational techniques in optical/IR astronomy. Optical/telescopes and their features (interferometers)Radio astronomy bands and observables . Radio interferometry x- & R- ray astronomy. Data handling in astronomy.

*(2 units)*

**PHY 654 Galactic and Extragalactic Radio Astronomy**

Continuum radiation from the galaxy, supernova, galactic centre, H11 regions radio emission, nebulae, radio stars, pulsars, H1 region, radio astronomy investigation of interstellar molecules, Extra-galactic radio astronomy; survey. Interpretation of spectra, polarization: structure and redshit dependent properties of sources. Theory of radio sources, radiation theory, source models statistics of sources and related topics.

*(2 units)*

**PHY 655 Random Signal and Noise Processing**

Review of random variables and probability distributions. Correlations and Convolutions. Sampling and sampling theorem. Special analysis of periodic and arbitrary functions. Spectral density of random signals. Shott noise in electronic device. Thermal noise and its statistical properties. Band limited Noise. Noise figure and equivalent noise temperature of amplifiers and receivers. Response of square-law and linear detectors to noise. Detection of radio and microwave signals immersed in noise, likelihood tests and statistical estimation.

*(2units)*

**PHY 656 Radio Astronomy & Its Instrumentation**

Radio-telescope: single dish, interferometer and arrays. Antenna and feed, wave guides. Radio receivers. Microwave components such as mixers, splitter, detectors, correlators, and spectrometers, processing hardware, data processing and display. Radio transmitter. Satellite and its payload. Basic measurement: Flux density scales and radio Spectra, polarization, angular measurements. Calibration of radio telescope, observing procedures and analysis of observations. Antenna measurements: antenna pattern, radiation efficiencies, gain and directivity, polarization.

*(2 units)*

**PHY 657 Plasma Physics**

Collision free plasma theory: particle orbit theory, adiabatic invariants, plasma wave, resonances and instabilities, chocks. Collision dominated plasma theory, Boltzman equations and moments leading to MHD flow problem, Magnetosonic waves and shocks, hydromagnetics equilibria and stability energy principles, Rayleigg-Taylor instabilities, Onsager relations.

*(2 units*)

**F. ELECTIVE COURSES FOR ATMOSPHERIC PHYSICS**

**PHY 660 Meteorology**

Climatology: Climate modeling. Dynamic of fronts, storms and tornadoes. Physics of cloud: Cloud formation, absorption and scattering of light by cloud layers, radiative transfer, water droplet growth revapouration, transmission of electromagnetic wave through clouds, laboratory simulation of cloud and fogs, data collection with balloons, rockets, space shuttle and satellites. Data analysis and weather forecasting.*(2units)*

**PHY 661 Physics of Geomagnetic Phenomena**

Earth’s magnetic field in space: Geomagnetism; Origin and variation of the earth’s main field with time. Electromagnetic induction within the earth: The magnetic field in space; The magnetosphere and solar wind; Magnetosphere; Atmospheric waves theory of atmospheric waves in lower atmospheric tides; Waves in the ionosphere. The earth’s upper atmosphere: Ionospheric dynamo action; Ionospheric measurements; Ground based and space vehicles; Aeronomic reactions; Collision processes; Transport processes in the ionosphere; Optical and radio aurora airglow and radio waves. Geomagnetic activities: Solar terrestrial interaction; Coupling of sun’s magnetic field and earth’s magnetic field; Equatorial Electrojet (EEJ); Conductivity models of EEJ; Climate change.

*(2units)*

**PHY 662 Aeronomy**

General circulation. Atmospheric models. Molecular spectra of atmosphere constituents.Wave propagation, atmospheric turbulence. Hydromagnetic wave. Space plasmas, the solar wind, cosmic rays. Geomagnetic storms. Ionosphere physics. Auroral studies. Solar effects on the Earths electric field. Ion density measurements. The ozone distribution and its interaction with radiation. Aerosols and pollution.

*(2units)*

**PHY 663 Radio Propagation**

Ionosphere propagation – ordinary and extra-ordinary waves. Ionosonde and ionograms. Ionosphere parameters and their influence on radio communication. Solar terrestrial relation. Sudden Ionospheric disturbances and their influences on radio communication. Solar and geomagnetic activity indices, and their influence on low altitude satellite communication. Fading. Troposcatter propagation, propagation of VHF, VHF and UHF waves.

*(2units)*

**PHY 664 Physics of Remote Sensing**

Passive microwave remote sensing of the Earth’s surface. Analysis and interpretation methodology of Synthetic Aperture Rader (SAR) imagery, image analysis and information extraction. Remote Sensing systems and techniques. Remote sensing applications. Methods and systems for digital processing and analysis of data acquired by satellite and air-borne sensor, radiometric and geometric and image correction, map ratification of digital imagery, pattern recognition.

*(2units)*

**PHY 665 Communications and Satellite Technology**

Simple communication system – microwave components and applications. Satellite communication system and application, wave and optical communication systems; National and international communication system applications. Satellite technology; space craft dynamics and control, structures and mechanisms, artificial intelligence and expert systems for Satellite operations. Tracking systems and autonomous Systems.

*(2units)*

**Special Note:**

Phy 641, Phy 655 and Phy 657 may be taken from the Geophysics and Astrophysics options as well as any other suitable courses from these options.

**G. ELECTIVE COURSES FOR SOLAR ENERGY PHYSICS/MATERIALS**

**SCIENCE**

**PHY 670 Solar Energy Availability and Collections**

The structure and composition of the sun. Solar themo-nuclear reactions. Extra-terrestrial and terrestrial solar radiation. Attenuation of solar radiation. Equipment for the direct measurement of solar radiation. Indirect estimate from available models. Thermal collection, Methods of harnessing solar energy, Functions of different components of solar thermal collectors, analysis of thermal collectors, conversion efficiency of solar thermal collectors, solar photovoltaic collectors.

*(2units)*

**PHY 671 Solar Energy** **Conversions and Storage**

Photovoltaic effect; The theory of photovoltaic e.m.f. generation at shottky barrier; Analysis of the current voltage characteristics of solar cells under different solar intensities; solar cell parameters; lamination of various solar cells; photothermal conversion; solar cells. Photovoltaic devices: First generation: Crystalline Silicon; Second generation: Thin films, Dye sensitized solar cell, Organic solar cell; Third generation: Conversion efficiency of solar cells, solar energy storage devices, theory of selected solar energy storage systems, electrochemical cells, fuel cells, etc.

*(2units)*

**PHY 672 Synthesis of Nanomaterials and Nanostructures for Solar Energy Application**

Chemical and Physical concepts necessary to understand nanoscale materials: Quantum properties; charge confinement and nanoscale thermodynamics; surface and interfacial forces; nanomachines and nanostructures; self-organization and scaling. Underlying physical and chemical principles (Optics, organic chemistry and inorganic chemistry, colloid chemistry, surface and material science) for nanostructure formation using ‘top-down’ lithography (patterned optical exposure of photosensitive materials) and ‘bottom-up’ self assembly. Materials synthesis and processing by physical vapor deposition, chemical vapor deposition, others. Underlying physicochemical fundamentals are discussed and examples from the recent literature are used to exemplify the methods.

*(2units)*

**PHY 673 Characterization Methods for Nanomaterials and Nanostructures**

Nanomaterials and Nanostructure characterization methods. Optical characterizations: Spectrophotometers, Infrared Spectroscopy, Optical Microscopy, Ellipsometry, Photoluminescence (PL), Raman Spectroscopy. Chemical and Physical Characterization: Electron Beam Techniques, Scanning Electron Microscopy (SEM), Auger Electron Spectroscopy (AES), Electron Microprobe (EMP), Transmission Electron Microscopy (TEM), Electron Beam Induced Current (EBIC), Cathodeluminescence (CL), Low-Energy High-Energy Electron Diffraction (LEED). Ion Beam Techniques: Secondary Ion Mass Spectrometry (SIMS), Rutherford Backscattering Spectrometry (RBS). X-Ray and Gamma-Ray Techniques: X-Ray Fluorescence (XRF), X-Ray Photoelectron Spectroscopy (XPS), X-Ray Topography (XRT), Neutron Activation Analysis (NAA). Charged-based and Probe Characterization: Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Scanning Capacitance Microscopy (SCM), Scanning Kelvin Probe Microscopy (SKPM), Scanning Spreading Resistance Microscopy (SSRM), Ballistic Electron Emission Microscopy (BEEM). Examine the underlying principles of the techniques and limitations and how to interpret data from each method.

*(2units)*

**PHY 674 Semiconductor Physics**

Crystal properties, symmetry and imperfections. Energy bands, Electron dynamics, effective mass tensor, concept and properties of holes. Equilibrium distributions, density of states, Fermi energy and transport properties including Boltzmann’s equation. Continuity equation, diffusion and drift of carriers. Materials science of semiconductors, microelectronics technologies, device/circuit fabrication and packaging. Nanoscale Electronic and Photonic Devices: Introduces devices, device physics, characteristics and possible applications specific to the nanoscale; single electron transistor, carbon nanotube electronics, quantum dot devices, spin-polarized electronic and photonic devices.

*(2 units)*

**PHY 675 Experimental Study of Solar Energy**

Experimental study of the operations and performance of the following:

1. Selected Solar Photovoltaic Utilities
2. Selected Solar Photothermal Utilities
3. Selected Solar Energy Storage Units
4. Group seminar

*(2 units)*

**PHY 692 MSc. Seminar**

Presentation of a seminar based on an approved research topic being investigated by the student is a pre-requisite for graduation

*(3 units)*

**PHY 694 MSc. Project Report**

A comprehensive M.Sc research in a relevant area of specialization project report has to be submitted by the candidate which must be defended before a panel of external and internal examiners.

*(6 units)*

**DEPARTMENT OF PHYSICS AND ASTRONOMY**

**LISTOF POSTGRADUATE SUPERVISORS FOR MASTERS DEGREE (M.Sc)**

|  |  |  |  |
| --- | --- | --- | --- |
| S/N | NAME | Area of Specialization | Phone number /E-mail |
| 1 | Prof. J. O. Urama | Astrophysics | 08050764262  [johnson@hartrao.ac.za](mailto:johnson@hartrao.ac.za) |
| 2 | Prof. A. A. Ubachukwu | Astrophysics | 08037734303  ubachukwuanya@yahoo..com.co.uk |
| 3 | Prof. (Mrs) F. N. Okeke | Solid earth Geophysics/Atmospheric Physics | 08035079686  [franca.okeke@unn.edu.ng](mailto:franca.okeke@unn.edu.ng) |
| 4 | Prof. C. M. I. Okoye | Condensed Matter Physics | 07038766990  [cmi.okoye@unn.edu.ng](mailto:cmi.okoye@unn.edu.ng), [okoyecmi@yahoo.com](mailto:okoyecmi@yahoo.com) |
| 5 | Prof. (Mrs.) R. U. Osuji | Solar Energy Physics/Materials Science | 080343133351  rose.osuji@unn.edu.ng;uzoma |
| 6 | Prof. P. U. Asogwa | Solar Energy Physics/Materials Science | 08035364059  [paul.asogwa@unn.edu.ng](mailto:paul.asogwa@unn.edu.ng) |
| 7 | Prof. A. E. Chukwude | Astrophysics | 08039555777  [aus\_chukwude@yahoo.com](mailto:aus_chukwude@yahoo.com) |
| 8 | Prof. F. I. Ezema | Solar Energy Physics/Materials Science | 08036239214  [fabian.ezema@unn.edu.ng](mailto:fabian.ezema@unn.edu.ng) |
| 9 | Dr. B. A. Ezekoye | Solar Energy Physics/Materials Science | 08037786767  benjamin.ezekoye@unn.edu.ng |
| 10 | Dr. J. A. Alhassan | Astrophysics | 07060780727  jibrinalhasan2002@yahoo.com |
| 11 | Dr. R. N. C. Eze | Astrophysics | 08037791388  [Romanus.eze@unn.edu.ng](mailto:Romanus.eze@unn.edu.ng) |
| 12 | Dr. D. N. Obiora | Solid Earth Geophysics | 08038804735  [Daniel.obiora@unn.edu.ng](mailto:Daniel.obiora@unn.edu.ng) |
| 13 | Dr. (Mrs) V. A. Ezekoye | Solar Energy Physics/Materials Science |  |
| 14 | Dr. K. C. Okpala | Atmospheric Physics | 08034376366  [okpala@yahoo.com](mailto:okpala@yahoo.com) |
| 15 | Dr. F. C. Odo | Astrophysics | 08063201289  [finbarr.odo@unn.edu.ng](mailto:finbarr.odo@unn.edu.ng) |
| 16 | Dr. J. O. Chibueze | Astrophysics | 08038566877  [James.chibueze@unn.edu.ng](mailto:James.chibueze@unn.edu.ng) |

**DEPARTMENT OF PHYSICS AND ASTRONOMY POSTGRADUATE PROGRAMME CURRICULUM FOR DOCTORAL DEGREE (Ph.D)**

**Department Information**

The Department of Physics and Astronomy offers the following Postgraduate degree programmes:

Courses are offered in the following areas;

1. Condensed Matter Physics
2. Medical Physics
3. Theoretical High Energy Physics
4. Solid Earth Geophysics
5. Astrophysics
6. Atmospheric Physics
7. Solar Energy Physics / Materials Science

**Philosophy**

Physics is a fundamental science that exposes people to the basic laws of nature and the principles required to understanding these basic natural laws. Astronomy on the other hand introduces the students to the natural laws and principles of heavenly bodies that include the planets, galaxies and stars. It is therefore envisaged that students graduating from the department will have received sufficient training in various aspects of physics to enable them appreciate and interpret natural/physical phenomena from a scientific point of view.

**Objectives**

The aim of the post graduate (PG) programme in the Department of Physics is to impart sound knowledge in key areas of research and ultimately lead to the production of high level man power in these areas of Physics. The graduates from our PG programme are expected to develop a high degree of competence in thinking independently about research problems and seeking to provide insight into solutions using the techniques’ learned as physicists.

**Job Opportunities**

Successful graduates of the above degree programmes are well equipped for postgraduate studies and teaching in the relevant subject. Their training also prepares them for careers in Government Departments, e. g. Meteorology, Geological Survey, National Standard organization; in Industrial research Establishment e.g. Astronomical Observations NRAO, NAOJ, ESO, ALMA, FIIRO, PRODA, NASDRA, NASENI, NAEA, SHETSCO; In oil, steel and other industries; and commercial and technical firms needs the services of a physicist.

**ENTRY REQUIREMENTS**

**Ph.D Degree Programme**

**(a) Basic Admission requirement for Doctoral Programme**

Candidates for Ph.D. admission must satisfy the following conditions:

i) Candidates must have five credit passes including English, Mathematics, Physics and two relevant science subjects at ‘O’ Level.

ii) Candidates with Bachelor’s degrees from an approved university must obtain a minimum of second class lower division in Physics with a CGPA of 2.5.

iii) Candidates must have Academic Master’s degree in Physics with a CGPA of 3.5 and project report score not lower than 60% (B).

iv) Candidates must demonstrate adequate intellectual capacity, maturity and effective decision making and problem solving potentials.

(b) **Duration of Programme**

(i) A fulltime Academic Doctorate programme shall run for a minimum of 6 semesters and a maximum of 10 semesters.

(ii) Part-time Doctoral programmes shall run for a minimum of 8 semesters and a maximum of 12 semesters.

(iii) For extension beyond the specified maximum period, a special permission of Senate shall be required.

**Requirements of Graduation**

To be awarded a degree candidate must pass a minimum of 30 units courses made up as follow:

* Core courses of 27 units, including the general courses, thesis research project and seminars
* Elective courses of minimum of 3 units
* A student shall present at least two (6 units)
* A student for an Academic Ph.D degree programme shall carry out research in a relevant area of specialization and submit an acceptable thesis (12 units) which must be defended before a panel of external and internal examiners.

**STRESS AREAS**

General/Core courses 0

Condensed Matter Physics 1

Radiation and Medical Physics 2

Theoretical High Energy Physics 3

Solid Earth Geophysics 4

Astronomy 5

Atmospheric Physics 6

Solar Energy Physics/ Materials Science 7

Thesis / Seminar 9

**COURSES TO BE OFFERED FOR Ph.D PROGRAMME**

**GENERAL/CORE COURSES**

**FIRST SEMESTER**

**Course No**.

**CREDITUNITS**

PGC 701 Synopsis and Grant Writing 3

PHY 703 Computer Methods in Physics 3

PHY 705 Recent Advances in Physics 3

A minimum of one course in candidates special area 3\_

12

**SECOND SEMESTER**

**Course No.**

PHY 792 Seminars 6

PHY794 Thesis 12

**18**

**COURSES IN AREAS OF SPECIALIZATION**

For a student to be credited with specialization in any of the above mentioned areas, he/she must register for additional course of 3 credits minimum from the following courses in the various fields of specialization.

PHY 715: Advanced Experimental study of materials 3

PHY 729: Advanced Medical Instrumentation 3

PHY 735 Advances in Theoretical High Energy Physics 3

PHY 741: Operational Geophysics 3

PHY 751: Observational Astronomy 3

PHY 761: Tools in Atmospheric Physics 3

PHY 775: Advanced Experimental Study of Solar Energy 3

**COURSE DESCRIPTION**

**PGC 701 Synopsis and Grant Writing**

Identification of types and nature of grant writing; mining of grant application calls on the internet. Determining appropriate strategy for each grant application. Study of various grant application, budgeting and budget defense. Study of sample grant writings in various forms and writing of mock research and grants. Identification of University of Nigeria synopsis structure and requirements, (Introduction, Methology and Results). Determining the content of each sub-unit of the synopsis. Steps in writing of synopsis from the Dissertation Thesis document. Thesis document. Structural and language issue. Common errors in synopsis writing and strategist for avoiding them. The role of the student and the supervisor in the production of synopsis. Writing of mock synopsis. All registered Ph.D students must attend a solution-based interactive workshop to be organized by the School of Postgraduate Studies for a practical demonstration and application of the knowledge acquired from the course, conducted to selected experts *(3 units*)

**PHY 703 Computational Analysis in Physics**

Introduction to UNIX (diff. awk, gedit, vi) MATLAB array operations 2-D and 3-D Plots with Matlab calculus & transforms with matlab FORTRAN programming. Phython scripting and applications in physical problems, C & C+ + programming latex.

*(3 units)*

**PHY 705 Recent Advances in Physics**

Review of minimum of 20 journal papers on a topic other than the topic of research of the student in his/her area of specialization. [Astronomy and Astrophysics, Atmospheric Sciences Solar Physics, Solid State Physics, Geophysics, Theoretical Physics] *(3 units)*

**PHY 741: Operational Geophysics**

use of geophysical instruments, field work. Aeromagnetic maps and processing . General details of geophysical methods, processing and interpretations. Seminar **s.**

*(3 units)*

**PHY 751 Observational Astronomy**

**Sp**herical Astronomy Optical/astronomy, bands and features. Observational techniques in optical/IR astronomy. Optical/telescopes and their features (interferometers)Radio astronomy bands and observables . Radio interferometry x- & R- ray astronomy. Data handling in astronomy.

*(3 units)*

**PHY 761: Tools in Atmospheric Physics**

Weather instruments, Cosmic rays instruments, geomagnetic field instruments, remote sensing instruments, field measurements of atmospheric and geophysical parameters, processing and interpretation of atmospheric data, satellite applications, Seminar.

**PHY 775 Experimental Study of Solar Energy**

Experimental study of the operations and performance of the Following:

(a) Selected solar Photovoltaic Utilities

(b) Selected solar Photothermal Utilities

(c) Selected solar Energy Storage Units

(d) Group seminar *(3 Units)*

**DEPARTMENT OF PHYSICS AND ASTRONOMY**

**LIST OF POSTGRADUATE SUPERVISORS FOR DOCTORIAL DEGREE (Ph.D)**

|  |  |  |  |
| --- | --- | --- | --- |
| S/N | NAME | Area of Specialization | Phone number /E-mail |
| 1 | Prof. J. O. Urama | Astrophysics | 08050764262  [Johnson@hartrao.ac.za](mailto:Johnson@hartrao.ac.za) |
| 2 | Prof. A. A. Ubachukwu | Astrophysics | 08037734303  ubachukwuanya@yahoo..com.co.uk |
| 3 | Prof. (Mrs) F. N. Okeke | Solid earth Geophysics/Atmospheric Physics | 08035079686  [Franca.okeke@unn.edu.ng](mailto:Franca.okeke@unn.edu.ng) |
| 4 | Prof. C. M. I. Okoye | Condensed Matter Physics | 07038766990  [cmi.okoye@unn.edu.ng](mailto:cmi.okoye@unn.edu.ng), [okoyecmi@yahoo.com](mailto:okoyecmi@yahoo.com) |
| 5 | Prof. (Mrs.) R. U. Osuji | Solar Energy Physics/Materials Science | 080343133351  rose.osuji@unn.edu.ng |
| 6 | Prof. P. U. Asogwa | Solar Energy Physics/Materials Science | 08035364059  [paul.asogwa@unn.edu.ng](mailto:paul.asogwa@unn.edu.ng) |
| 7 | Prof. A. E. Chukwude | Astrophysics | 08039555777  [aus\_chukwude@yahoo.com](mailto:aus_chukwude@yahoo.com) |
| 8 | Prof. F. I. Ezema | Solar Energy Physics/Materials Science | 08036239214  fabian.ezema@unn.edu.ng |
| 9 | Dr. B. A. Ezekoye | Solar Energy Physics/Materials Science | 08037786767  benjamin.ezekoye@unn.edu.ng |