

# **MSc Astrophysics with Radio-astronomy & Applications - SC531 (Subject to Approval)**

## **1. Specific Titles**

- 1) MSc Astrophysics with Radio-astronomy & Applications
- 2) Postgraduate Diploma in Astrophysics with Radio-astronomy & Applications
- 3) Postgraduate Certificate in Astrophysics with Radio-astronomy & Applications

## **2. Objectives**

Astrophysics and in particular radio-astronomy are very multi-disciplinary fields. While theoretical aspects of the study of celestial objects and the Universe as a whole requires a good mastery of various branches of Physics, the development of the sensitive instrumentation (antennas and receiver systems) for radio-astronomy requires very good engineering skills. Computational skills are also required for the processing and analysis of data. The department of Physics has been active in the field of Radio-astronomy for over 20 years now, with the Mauritius Radio Telescope (MRT) as an important research facility. MRT has trained several engineering students. The MRT team is presently looking forward to an active participation in the international Square Kilometre Array (SKA) which will become the most powerful radio telescope in the world. New radio astronomy telescope arrays are being planned.

This program aims at enhancing the knowledge and skills of graduates, mainly in the field of Astrophysics and Radio-astronomy. Students will thus be well equipped for a research career in Astrophysics or Radio-astronomy. Thus, they will be able to take full advantage of the opportunities available through MRT, and its association with the SKA project. The skills gained in radio-astronomy can be applied to several other areas relying on similar technologies. Hence, our graduates may also opt for a wide range of careers in other fields. These can be communication, remote sensing, and fields requiring signal processing and image enhancement, such as medical imaging.

## **3. General Entry Requirements**

Successful completion of an undergraduate degree with

- at least a Second Class or CPA  $\geq 50\%$ , whichever is applicable or
- a GPA not less than 2.5 out of 4 or equivalent, from a recognised higher education institution.

**OR** alternative qualifications acceptable to the University of Mauritius.

## **4. Programme Requirements**

BSc (Hons) Physics or BSc (Joint Hons) Degree with Physics as one of the subjects or equivalent qualifications acceptable to the University of Mauritius. Students with undergraduate degrees in electrical and electronics engineering or related engineering fields (to be determined by the department of Physics) will also be accepted.

## **5. General and Programme Requirements – Special Cases**

The following may be deemed to have satisfied the General and Programme requirements for admission:

- (i) Applicants who do not satisfy any of the requirements as per Regulations 3 and 4 above but who submit satisfactory evidence of having passed examinations which are deemed by the Senate to be equivalent to any of those listed.

(ii) Applicants who do not satisfy any of the requirements as per Regulations 3 and 4 above but who in the opinion of Senate submit satisfactory evidence of the capacity and attainments requisite to enable them to pursue the programme proposed.

(iii) Applicants who hold a full practising professional qualification obtained by examination.

## 6. Programme Duration

The Programme will be offered on a full-time (F/T) basis and exceptionally on a part-time (P/T) basis. The duration of the Postgraduate Programme should normally not exceed 2 years (4 semesters) for F/T and 4 years (8 semesters) for P/T.

7. **Credits per Semester:** Minimum 3 credits subject to Regulation 6.

## 8. Minimum Credits Required for Awards

Master's Degree: 39  
Postgraduate Diploma: 24  
Postgraduate Certificate: 12

Breakdown as follows:

	<b>Core Taught modules</b>	<b>Project</b>	<b>Electives</b>
Master's Degree	18	12	9 <sup>a</sup>
Postgraduate Diploma	18		6 <sup>b</sup>
Postgraduate Certificate	12		

<sup>a</sup>A minimum of 9 credits from electives with a PHYAS code.

<sup>b</sup>A minimum of 6 credits from electives with a PHYAS code

## 9. Assessment

Each module can either be taught in semester 1 only or in semester 2 only or throughout the two semesters.

Modules wholly taught in one semester are termed semester modules whereas modules taught throughout the two semesters are termed yearly modules.

Each module will carry 100 marks and will be assessed as follows (unless otherwise specified):

Assessment will be based on a written examination of 3-hour duration and continuous assessment carrying a range of 30% to 40% of total marks. Continuous assessment may be based on laboratory works and/or assignments and/or seminars and should include at least 1 class test.

Written examinations for semester modules will be held in the semester they are taught in. Yearly modules will be examined at the end of the year.

An overall total of 40% for combined Continuous Assessment and Written Examination components would be required to pass a module, without minimum thresholds within the individual Continuous Assessment and Written Examination.

## 10. Plan of Study

Students are required to submit at the end of Semester 1 a Plan of Study for their whole Programme of Studies, indicating the list of elective modules and in which semester each of them will be taken.

The University reserves the right not to offer a given elective module if the critical number of students is not attained and/or for reasons of resource constraints.

## 11. Important Note

The rules as stipulated in this Programme Structure and Outline Syllabus will replace all other rules and regulations found in previous Programme Structures.

## 12. List of Modules

Code	Module Name	Hrs/Wk L + P	Credits
<b><u>CORE MODULES</u></b>			
PHYAS 6001(7)	General Astrophysics	2.5 + 0	2.5
PHYAS 6002(7)	Radio-astronomy fundamentals	2.5 + 0	2.5
PHYAS 6003(7)	Stellar Astrophysics	3 + 0	3
PHYAS 6004(7)	Physical Processes in Astrophysics	3.5 + 0	3.5
PHYAS 6005(7)	Galactic and Extragalactic Astronomy	3.5 + 0	3.5
PHYAS 6006(7)	Multi-wavelength Astrophysical Techniques	2.5 + 1	3
<b><u>PROJECT</u></b>			
PHYAS 6000Y(7)	Research Project	-	12
<b><u>ELECTIVES</u></b>			
PHYAS 6007(7)	General Relativity & Physical Cosmology	3 + 0	3
PHYAS 6008(7)	Pulsar Astronomy	2.5 + 1	3
PHYAS 6009(7)	Antenna Systems for Radio Telescopes and other applications	2.5 + 1	3
PHYAS 6010(7)	Receiver Systems for Radio Telescopes and other applications	2.5 + 1	3
PHYAS 6011(7)	Signal and Image Processing for Astronomical and other data	2.5 + 1	3
PHYAS 6012(7)	Computational Astronomy & Astrophysics	1 + 4	3

And/or other modules approved by the department.

**Note:** Not all electives may be on offer. The list of modules is not exhaustive.

### 13. Programme Plan - MSc Physics

#### Full-Time

		<b>YEAR 1</b>	
<b>Code</b>	<b>Module Name</b>	<b>Hrs/Wk L+P</b>	<b>Credits</b>
<b>CORE</b>			
PHYAS 6000Y(7)	Research Project	-	-
PHYAS 6001(7)	General Astrophysics	2.5 + 0	2.5
PHYAS 6002(7)	Radio-astronomy fundamentals	2.5+0	2.5
PHYAS 6003(7)	Stellar Astrophysics	3 + 0	3
PHYAS 6004(7)	Physical Processes in Astrophysics	3.5 + 0	3.5
PHYAS 6005(7)	Galactic and Extragalactic Astronomy	3.5 + 0	3.5
PHYAS 6006(7)	Multi-wavelength Astrophysical Techniques	2.5 + 1	3
<b>ELECTIVES</b>			
PHYAS 6007(7)	General Relativity & Physical Cosmology	3 + 0	3
PHYAS 6008(7)	Pulsar Astronomy	2.5 + 1	3
PHYAS 6009(7)	Antenna Systems for Radio Telescopes and other applications	2.5 + 1	3
PHYAS 6010(7)	Receiver Systems for Radio Telescopes and other applications	2.5 + 1	3
PHYAS 6011(7)	Signal and Image Processing for Astronomical and other data	2.5 + 1	3
PHYAS 6012(7)	Computational Astronomy & Astrophysics	1 + 4	3

And/or other modules approved by the department.

**Note:** Not all electives may be on offer. The list of modules is not exhaustive.

#### Part-Time

		<b>YEAR 1</b>	
<b>Code</b>	<b>Module Name</b>	<b>Hrs/Wk L+P</b>	<b>Credits</b>
<b>CORE</b>			
PHYAS 6001(7)	General Astrophysics	2.5 + 0	2.5
PHYAS 6002(7)	Radio-astronomy fundamentals	2.5+0	2.5
PHYAS 6003(7)	Stellar Astrophysics	3 + 0	3
PHYAS 6004(7)	Physical Processes in Astrophysics	3.5 + 0	3.5
PHYAS 6005(7)	Galactic and Extragalactic Astronomy	3.5 + 0	3.5
PHYAS 6006(7)	Multi-wavelength Astrophysical Techniques	2.5 + 1	3

		<b>YEAR 2</b>	
<b>Code</b>	<b>Module Name</b>	<b>Hrs/Wk L+P</b>	<b>Credits</b>
<b>CORE</b>			
PHYAS 6000Y(7)	Research Project	-	-

#### **ELECTIVES**

PHYAS 6007(7)	General Relativity & Physical Cosmology	3 + 0	3
PHYAS 6008(7)	Pulsar Astronomy	2.5 + 1	3
PHYAS 6009(7)	Antenna Systems for Radio Telescopes and other applications	2.5 + 1	3
PHYAS 6010(7)	Receiver Systems for Radio Telescopes and other applications	2.5 + 1	3
PHYAS 6011(7)	Signal and Image Processing for Astronomical and other data	2.5 + 1	3
PHYAS 6012(7)	Computational Astronomy & Astrophysics	1 + 4	3

And/or other modules approved by the department.

**Note:** Not all electives may be on offer. The list of modules is not exhaustive.

#### 14. Outline Syllabus

This outline syllabus is not prescriptive and is intended to serve as a guide only.

##### **CORE MODULES**

##### **PHYAS 6000Y(7) - RESEARCH PROJECT**

The student must undertake a research project in an Astrophysics/Radio-astronomy topic, or in an area where similar techniques are applied, as approved by the department. The student will work under the guidance of an academic staff of the department with the possibility of a joint supervisor outside the department, depending on the topic chosen and the expertise available within or outside of the department.

##### **PHYAS 6001(7) - GENERAL ASTROPHYSICS**

Astronomical objects and their distribution in the Universe. Our Solar System. Determination of stellar distances. Brightness, Luminosity and effective temperature of stars. Binary stars. Masses and radii of stars and their determination. Observed mass-luminosity relations. Observed colour magnitude diagrams. Introduction to stellar interiors and stellar models (hydrostatic equilibrium, pressure and temperature inside stars). Introduction to Galactic and Extragalactic Astronomy. Cosmology concepts.

##### **PHYAS 6002(7) - RADIOASTRONOMY FUNDAMENTALS**

Electromagnetic spectrum and Radio Sky. Brightness, Flux Density, Luminosity. Radio emission mechanisms. Thermal and Non thermal emission. Sensitivity and Resolving power. Galactic radio sources (Sun, pulsars, supernova remnants, HI and HII regions etc). Extragalactic radio sources.

##### **PHYAS 6003(7) - STELLAR ASTROPHYSICS**

Observational data on stars (Mass, Luminosity, effective temperatures and colour magnitude diagrams). Spectral classification of stars and stellar atmospheres. Stellar structure and evolution: composition of stars, energy generation & energy transport in stars, the interstellar medium (ISM) and formation of stellar clusters, evolutionary tracks of stars of different masses in the colour magnitude diagram, star deaths and age of star clusters. Population I and II stars and their distribution in our Galaxy. Stellar magnetic fields. Pulsating stars. The end states of stars (white dwarfs & planetary nebulae, neutron stars & supernova remnants).

##### **PHYAS 6004(7) – PHYSICAL PROCESSES IN ASTROPHYSICS**

Fundamentals of radiative transfer. Astrophysical processes occurring in the universe: synchrotron radiation, thermal absorption, synchrotron self-absorption, Bremsstrahlung, Compton scattering, Plasma effects, etc. Spectra of radio sources. Atomic structure. Molecular structure.

##### **PHYAS 6005(7) – GALACTIC AND EXTRAGALACTIC ASTRONOMY**

Stellar evolution in galaxies. Morphology of galaxies. The Milky Way as a Galaxy. Structure of the Galaxy. Kinematics of the Galaxy. Scaling relations. Luminosity function of Galaxies. Galaxies as gravitational lenses. Population synthesis. Nucleosynthesis and Chemical Evolution of Galaxies. Galaxy Formation and

Evolution. Active Galactic Nuclei (AGNs). Clusters of Galaxies. The Dark Matter problem. Candidates for Dark Matter.

#### **PHYAS 6006(7) – MULTIWAVELENGTH ASTROPHYSICAL TECHNIQUES**

Brief historical development of observational astronomy. Transparency of the Earth's atmosphere and ionosphere to EM waves. Observational techniques used for different parts of the EM spectrum (Optical & Infra-red, Radio & microwave, X-ray & Gamma-ray). Virtual observatories and Data Mining. Introduction to multi-wavelength analysis. Other astronomical windows. Coordinate systems used in astronomy and their applications.

#### **ELECTIVE MODULES**

#### **PHYAS 6007(7) – GENERAL RELATIVITY AND PHYSICAL COSMOLOGY**

Brief review of Special Relativity. Introduction to General Relativity. General tensor calculus. Riemannian space. The General Theory of Relativity. Some predictions and tests of General Relativity. Standard Cosmology. Thermal History of the Universe. Big-Bang nucleosynthesis. The Cosmic Microwave Background Radiation (CMBR). X-ray Emission from Clusters of Galaxies. Gravitational Lensing. Sunyaev-Zeldovich effect. Large scale structures, Inhomogeneities in the Universe. Cosmological parameters. The Universe at High redshift. The Dark Energy Problem.

#### **PHYAS 6008(7) - PULSAR ASTRONOMY**

Star deaths and the formation of compact objects. Neutron star models. Observational properties of Pulsars - single pulse properties and average profiles, classification of pulsars, normal pulsars, binary and millisecond pulsars, pulsars detected outside the radio region. Pulsar models, radiation processes and pulsar emission mechanisms. Galactic distribution of pulsars and supernovae, pulsar-supernova associations, propagation effects of the interstellar medium (ISM) on observed radio pulses and pulsar distances. Pulsars as physical tools (probes of the ISM, high-precision time keeping, gravitational physics in the strong field regime). Instrumentation, observational and data processing techniques in Pulsar Astronomy at radio wavelengths for incoherent and coherent de-dispersion. Achievements, present challenges and opportunities in Pulsar Astronomy.

#### **PHYAS 6009(7) - ANTENNA SYSTEMS FOR RADIO TELESCOPES AND OTHER APPLICATIONS**

Filled-aperture (dishes) and non-filled-aperture antennas (dipoles antenna). Theory of Interferometers and Correlator Arrays. Different types of Interferometers. Aperture Synthesis. Interferometry and Fourier Imaging in Astronomy. Design of Arrays. Techniques used in different types of Radiotelescopes. Applications in other fields.

#### **PHYAS 6010(7) – RECEIVER SYSTEMS FOR RADIO TELESCOPES AND OTHER APPLICATIONS**

Front end Antenna systems: Amplifiers, Filters, Mixers, Phase Shifters etc. Back end receiver systems (Analog and Digital). Digital Correlators for Continuum Observations. Digital Correlators for Spectral-line Observations. Radiometers. Masers. Tracking Systems. Pulsar receivers. Applications in other fields.

#### **PHYAS 6011(7) - SIGNAL AND IMAGE PROCESSING FOR ASTRONOMICAL AND OTHER DATA**

Continuous and discrete signals. Calibration of Data. Correlation. Transforms. Convolution and Deconvolution. Noise. Filtering. Component analysis. Synthesis Imaging. Wide Field Imaging Deconvolution algorithms (CLEAN, MEM,..) . Calibration of Images. Applications in other fields.

#### **PHYAS 60 12(7) – COMPUTATIONAL ASTRONOMY & ASTROPHYSICS**

Computational Methods. Use and Applications of Astronomical softwares for Astronomical Data Processing. Applications in other fields.

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