# UNIVERSITY OF MADRAS

## M.Sc. DEGREE PROGRAMME IN PHYSICS

SYLLABUS WITH EFFECT FROM 2023-2024

| **Paper 13 - NUCLEAR AND PARTICLE PHYSICS** | **II YEAR - FOURTH SEMESTER** |
|---|---|

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **Credits** | **Inst. Hours** | **Marks** |
|---|---|---|---|---|---|---|---|---|
| 529C4A | **NUCLEAR AND PARTICLE PHYSICS** | Core | | | | 4 | 6 | 75 |

| **Pre-Requisites** |
|---|
| Knowledge of basic structure of atom and nucleus. |
| **Learning Objectives** |
| ➢ Introduces students to the different models of the nucleus in a chronological order<br>➢ Imparts an in-depth knowledge on the nuclear force, experiments to study it and the types of nuclear reactions and their principles<br>➢ Provides students with details of nuclear decay with relevant theories<br>➢ Exposes students to the Standard Model of Elementary Particles and Higgs boson |

| **UNITS** | **Course Details** |
|---|---|
| **UNIT I:**<br>**NUCLEAR MODELS** | Liquid drop model – Weizacker mass formula – Isobaric mass parabola –Mirror Pair - Bohr Wheeler theory of fission – shell model – spin-orbit coupling – magic numbers – angular momenta and parity of ground states – magnetic moment – Schmidt model – electric Quadrapole moment - Bohr and Mottelson collective model – rotational and vibrational bands. |
| **UNIT II:**<br>**NUCLEAR FORCES** | Nucleon – nucleon interaction – Tensor forces – properties of nuclear forces – ground state of deuteron – Exchange Forces - Meson theory of nuclear forces – Yukawa potential – nucleon-nucleon scattering – effective range theory – spin dependence of nuclear forces - charge independence and charge symmetry – isospin formalism. |
| **UNIT III:**<br>**NUCLEAR REACTIONS** | Kinds of nuclear reactions – Reaction kinematics – Q-value – Partial wave analysis of scattering and reaction cross section – scattering length – Compound nuclear reactions – Reciprocity theorem – Resonances – Breit Wigner one level formula – Direct reactions - Nuclear Chain reaction – four factor formula. |

| | |
|---|---|
| **UNIT IV:**<br><br>**NUCLEAR DECAY** | Beta decay – Continuous Beta spectrum – Fermi theory of beta decay - Comparative Half-life –Fermi Kurie Plot – mass of neutrino – allowed and forbidden decay — neutrino physics – Helicity - Parity violation - Gamma decay – multipole radiations – Angular Correlation - internal conversion – nuclear isomerism – angular momentum and parity selection rules. |

| | |
|---|---|
| **UNIT V:**<br><br>**ELEMENTARY PARTICLES** | Classification of Elementary Particles – Types of Interaction and conservation laws – Families of elementary particles – Isospin – Quantum Numbers – Strangeness – Hypercharge and Quarks –SU (2) and SU (3) groups-Gell Mann matrices– Gell Mann Okuba Mass formula-Quark Model. Standard model of particle physics – Higgs boson. |
| **UNIT VI: PROFESSIONAL COMPONENTS** | Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism |
| **TEXT BOOKS** | 1. D. C. Tayal – Nuclear Physics – Himalaya Publishing House (2011)<br>2. K. S. Krane – Introductory Nuclear Physics – John Wiley & Sons (2008)<br>3. R. Roy and P. Nigam – Nuclear Physics – New Age Publishers (1996)<br>4. S. B. Patel – Nuclear Physics – An introduction – New Age International Pvt Ltd Publishers (2011)<br>5. S. Glasstone – Source Book of Atomic Energy – Van Nostrand Reinhold Inc.,U.S.- 3rd Revised edition (1968) |
| **REFERENCE BOOKS** | 1. L. J. Tassie – The Physics of elementary particles – Prentice Hall Press (1973)<br>2. H. A. Enge – Introduction to Nuclear Physics – Addison Wesley, Publishing Company. Inc. Reading. New York, (1974).<br>3. Kaplan – Nuclear Physics – 1989 – 2nd Ed. – Narosa (2002)<br>4. Bernard L Cohen – Concepts of Nuclear Physics – McGraw Hill Education (India) Private Limited; 1 edition (2001)<br>5. B.L. Cohen, 1971, Concepts of Nuclear Physics, TMCH, New Delhi. |
| **WEB SOURCES** | 1. http://bubl.ac.uk/link/n/nuclearphysics.html<br>2. http://www.phys.unsw.edu.au/PHYS3050/pdf/Nuclear_Models.pdfhttp://www.scholarpedia.org/article/Nuclear_Forces<br>3. https://www.nuclear-power.net/nuclear-power/nuclear-reactions/<br>4. http://labman.phys.utk.edu/phys222core/modules/m12/nuclear_models.html<br>5. https://www.ndeed.org/EducationResources/HighSchool/Radiography/radioactivedecay.html |

# UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN PHYSICS

SYLLABUS WITH EFFECT FROM 2023-2024

**COURSE OUTCOMES:**

**At the end of the course, the student will be able to:**

| | | |
|---|---|---|
| **CO1** | Gain knowledge about the concepts of helicity, parity, angular correlation and internal conversion. | **K1, K5** |
| **CO2** | Demonstrate knowledge of fundamental aspects of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of radiation and matter. | **K2, K3** |
| **CO3** | Use the different nuclear models to explain different nuclear phenomena and the concept of resonances through Briet-Weigner single level formula | **K3** |
| **CO4** | Analyze data from nuclear scattering experiments to identify different properties of the nuclear force. | **K3, K4** |
| **CO5** | Summarize and identify allowed and forbidden nuclear reactions based on conservation laws of the elementary particles. | **K5** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate** | | |

**MAPPING WITH PROGRAM OUTCOMES:**

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 |
| **CO4** | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 |
| **CO5** | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |

| | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** | **PSO7** | **PSO8** | **PSO9** | **PSO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 |
| **CO4** | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 |
| **CO5** | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |