# Nuclear and High Energy Physics

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| Program | **MS/PhD** |
| Credit Hours | **3** |
| Duration | **16-Weeks** |
| Prerequisites | **Quantum Mechanics, Mathematical methods of Physics** |
| Resource Person | **Dr. M. Imran Jamil** |
| Counseling Timing | **Wednesday: 11:00am-01:00pm**  **Thursday: 2pm-4pm** |

**Chairman/Director Program signature………………. Dean’s signature…………**

**Date………………………………….**

**Learning Objective**

**Credit Hours:3**

**Resource Person: Dr. M. Imran Jamil Semester: Spring-2021**

**Objective:** The basic purpose of this course is the study of fundamental particles and their interactions. After the completion of this course the participant will be in a better position to understand both the particle physics and the field theories. These are the two basic ingredients of Standard Model the so called theory of everything.

**Syllabus:** Fundamental Particles and Interactions, Quantum Numbers and the JPC , Element of group theory, group representations, reducible and irreducible representations, Lie group, Lie Algebra, Casimir operators, matrix representation of generators of SU(2), SU(3), roots of SU(2) and SU(3), weights of various representations of SU(2) and SU(3), Young’s tableaux and irreducible representations of SU(2) and SU(3) groups, decomposition of the product of irreducible representations, Sakata Model, eightfold way, quark model. The Classical Field, The Gauge Invariance, Dyson Expansion of the S-Matrix, Feynman Diagrams.

**Learning Methodology**

There will be one class of three hours each week. In addition, students should expect to spend at least nine hours each week on their homework.

**Recommended Books**

1. B. R. Martin and G. Shaw, Particle Physics, John Wiley and Sons, Ltd, 2008.
2. *David Griffiths, Introduction to Elementary Particles,* *JOHN WILEY & SONS, INC., 1987.*
3. Morton Hamermesh, *Group theory and its application to physical problems*, Addison Wesley, 1989.
4. M. Saleem, M. Rafique, Group theory for high energy physicist, CRC Press (Taylor and Francis Group), 2013.
5. Quantum Field Theory by F. Mandl and G. Shaw, John Wiley & Sons (1984).

**Reference Books**

1. J. P. Elliot and P. G. Dawber, *Symmetry in physics*, Vol. 1 and 2, The Macmillan Press Ltd, 1979.
2. Fl. Stancu, *Group theory in subnuclear physics*, Clarendon press, Oxford, 1996.
3. W. U. Ki Tung, *Group theory in physics*, World Scientific, 2003.
4. F. Halzen and A. D. Martin, *Quarks and leptons*, John Wiley and Sons, 1984.
5. An Introduction to Quantum Field Theory by Michael E. Peskin andDaniel V. Schroeder, Addison-Wesley Publishing Company (1995).
6. The Quantum Theory of Fields, V-I,II by Steven Weinberg, Cambridge University Press (1995)

**Calendar of Course contents to be covered during semester**

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| **Week** | **Activity** | **Reference** |
| WEEK-1 | Fundamentals of High Energy Physics | *Martin and Shaw, David Griffiths* |
| WEEK-2 | Fundamentals of High Energy Physics | *Martin and Shaw, David Griffiths* |
| WEEK-3 | Some characteristics of group elements, Permutation group, Multiplication table. Subgroups, Mapping, Homomorphism, Isomorphism, Direct Product of groups. | Morton Hamermesh,  M. Saleem |
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| WEEK-4 | Group representation, Reducible and irreducible representations, Construction of Representations by addition, Analysis of representations. | Morton Hamermesh,  M. Saleem |
| WEEK-5 | Groups of linear transformations, order of a group of transformations. | Morton Hamermesh,  M. Saleem |
| WEEK-6 | Lie groups, Generators of Lie group. Generators of SU(2). | Morton Hamermesh,  M. Saleem |
| WEEK-7 | Generators of SU(3), Generators and parameterization of a group, matrix representation of generators | Morton Hamermesh,  M. Saleem |

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| WEEK-8 | Commutation relations between the generators of a semisimple Lie group, Properties of the Roots. Roots of SU(2), roots of SU(3) | Morton Hamermesh,  M. Saleem |
| WEEK-9 | Weights of various representations of SU(2) and SU(3). | Morton Hamermesh,  M. Saleem |
| WEEK-10 | Young’s tableaux and irreducible representations of SU(2) and SU(3) groups, decomposition of the product of irreducible representations. | Morton Hamermesh,  M. Saleem |
| WEEK-11 | Sakata Model, eightfold way, quark model. | Morton Hamermesh,  M. Saleem |
| WEEK-12 | The Classical Field, Harmonic Oscillator | Mandl and Shaw |
| WEEK-13 | The Gauge Invariance  Dyson Expansion of the S-Matrix | Mandl and Shaw |
| WEEK-14 | Feynman Diagrams in the Position Space | Mandl and Shaw |
| WEEK-15 | Feynman Diagrams in the Momentum Space | Mandl and Shaw |