UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that the Syndicate at its meeting held on 27-07-2023 has approved the recommendations of the Academic Council made at its meetings dated 24-05-2023 regarding approval of the new optional/Elective Courses for MS/Ph.D. (Physics) Program under semester System w.e.f. the Academic Session, Fall, 2022.

The Syllabi & Courses of Reading for new optional/Elective Courses for MS/Ph.D. (Physics) Program under semester System is enclosed herewith, vide Annexure-'A'

Sd/-
Registrar

Admin. Block,
Quaid-i-Azam Campus, Lahore.

No. D/ 7091 /Acad. **Dated: 08- 09 /2023.**

Copy of the above is forwarded to the following for information and further necessary action: -

1. Dean, Faculty of Sciences
2. Chairman, Department of Physics
3. Chairperson, DPCC
4. Controller of Examinations.
5. Director, IT for placement at website.
6. Admin. Officer (Statutes)
7. Secretary to the Vice-Chancellor
8. PS to the Registrar.
9. Assistant Syllabus.

Assistant Registrar (Academic)
for Registrar

Annexure-A

Department of Physics
Faculty of Science
University of the Punjab, Lahore

Course Outline

Programme	MPhil	Course Code	5323	Credit Hours	3
Course Title	**Detector Physics**				

Course Introduction

In this course, particle detectors are described which are in use in elementary particle physics, in cosmic ray studies, in high energy astrophysics, nuclear physics, and in the fields of radiation protection, biology and medicine. Apart from the description of the working principles and characteristic properties of particle detectors, fields of application of these devices are also part of this course.

Learning Outcomes

On the completion of the course, the students will:

1. Demonstrate the basic concept of different detectors and their principles.
2. Identify the particles and construct the event.
3. .Calculate the mass of particles by measuring the momentum and either the velocity or the energy.
4. Apply detectors in different areas of science.
5. Understand the modern large scale detectors, like CERN, ATLAS and BESIII etc.

Course Content

Week 1	**Unit-I Units of radiation measurements and radiation sources** 1.1 Nuclear level diagram 1.2 Alpha, Beta and Gamma emission 1.3 Electron capture 1.4 Annihilation radiation 1.5 Internal conversion 1.6 Auger electron 1.7 Neutron sources
Week (2 & 3)	**Unit-II Interactions of particles and radiation with matter** 2.1Preliminary notations and Definitions 2.1.1 The Cross section 2.1.2 Interaction probability in a distance x. Mean free path 2.1.3 Surface density units 2.2 Energy loss of heavy charged particles by atomic collisions 2.2.1 Bohr's calculation- The classical case 2.2.2 Bathe- Bloch formula 2.2.3 Energy dependence 2.2.4 Scaling law for dE/dx 2.2.5 Mass stopping power 2.2.6 dE/dx for mixtures and compounds 2.2.7 Limitations of the Bathe-Bloch formula 2.2.8 Channeling and Range

Week (4 & 5)	**Unit-III Energy losses during collision** 3.1 Energy loss of electrons and positrons 3.1.1 Collision loss 3.1.2 Energy loss by Bremstrahlung 3.1.3 Electron-electron Bremstrahlung 3.1.4 Critical energy 3.1.5 Radiation length 3.1.6 Range of electrons 3.1.7 The absorption of Beta electrons 3.2 Multiple coulomb scattering 3.2.1 Back scattering of low energy electrons 3.3 Energy Straggling: The energy loss distribution 3.3.1 Thick absorbers: The Gaussian limit 3.3.2 Very thick absorbers 3.3.3 Thin absorbers 3.4 The Interaction of photons 3.4.1 Photoelectric effect 3.4.2 Compton effect 3.4.3 Pair production 3.4.4 Electron-photon shower 3.4.5 Total photon absorption cross section
Week 6	**Unit-IV General Characteristic of detectors** 4.1 Sensitivity 4.2 Detector response 4.3 Energy resolution. The Fano Factor 4.4 Response time 4.5 Detector efficiency 4.6 Dead time
Week (6 & 7)	**Unit-V Main physical phenomena used for particle detection and basic counter types** 5.1 Ionization counters 5.1.1 Ionization counters without amplification 5.1.2 Proportional counters 5.1.3 Geiger counters 5.1.4 Streamer tubes 5.2 Ionization detectors with liquids 5.3 Solid-state ionization counters 5.4 Scintillation counters 5.5 Photomultipliers and photodiodes 5.6 Cherenkov counters 5.7 Transition-radiation detectors (TRD)
Week (8 & 9)	**Unit-VI Track detectors** 6.1 Multiwire proportional chambers 6.2 Planar drift chambers 6.3 Cylindrical wire chambers 6.3.1 Cylindrical proportional and drift chambers 6.3.2 Jet drift chambers 6.3.3 Time-projection chambers (TPCs) 6.4 Micro pattern gaseous detectors 6.5 Semiconductor track detectors 6.6 Scintillating fibre trackers

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Week 10	**Unit-VII Calorimetry** 7.1 Electromagnetic calorimeters 7.1.1 Electron–photon cascades 7.1.2 Homogeneous calorimeters 7.1.3 Sampling calorimeters 7.2 Hadron calorimeters 7.3 Calibration and monitoring of calorimeters 7.4 Cryogenic calorimeters
Week 11	**Unit-VIII Particle identification** 8.1 Charged-particle identification 8.1.1 Time-of-flight counters 8.1.2 Identification by ionization losses 8.1.3 Identification using Cherenkov radiation 8.1.4 Transition-radiation detectors 8.2 Particle identification with calorimeters 8.3 Neutron detection
Week 12	**Unit-IX Neutrino detectors** 9.1 Neutrino sources 9.2 Neutrino reactions 9.3 Some historical remarks on neutrino detection 9.4 Neutrino detectors
Week 13	**Unit-X Momentum measurement and muon detection** 10.1 Magnetic spectrometers for fixed-target experiments 10.2 Magnetic spectrometers for special applications **Unit-XI Ageing and radiation effects** 11.1 Ageing effects in gaseous detectors 11.2 Radiation hardness of scintillators 11.3 Radiation hardness of Cherenkov counters 11.4 Radiation hardness of silicon detectors
Week 14	**Unit-XII Example of a general-purpose detector: BESIII (Beijing Spectrometer III)** 12.1 Detector components 12.1.1 Main drift chamber 12.1.2 Time-of-flight counters (TOF) 12.1.3 Electromagnetic calorimeter (ECL) 12.2 Particle identification 12.4 Luminosity measurement and the detector performance
Week 15	**Unit-XIII Applications of particle detectors outside particle physics** 13.1 Radiation camera 13.2 Imaging of blood vessels 13.3 Tumour therapy with particle beams 13.4 Random-number generators using radioactive decays
Week 16	**Unit-XIV Introduction to Detector Simulations** 13.1 GEANT (Geometry and Tracking Tool Kit)-4, Detector simulation tool kit

Textbooks and Reading Material

1. Claus Grupen, Boris Shwartz, Particle Detectors, 2nd Edition, Cambridge Universuity Press, 2008.
2. D. Green, The Physics of Particle Detectors, 1st Ed., Cambridge University Press, 2000.
3. William R Leo, Experimental Techniques in Nuclear and Particle Physics, 1st Edition, Spriger Verlog 1987.
4. *https://geant4.web.cern.ch.* retrieved on 17-05-2023.

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5. *http://english.ihep.ac.cn.* Beijing Spectrometer(BEII) Experiment----Institute of High Energy Physics (cas.cn) retrieved on 17-05-2023

1. **Suggested Readings**

1. R. K. Bock and A. Vasilescu, The Particle Detector Brief Book, CERN, 1998.
2. K. Kleinknecht, Detectors for Particle Radiation, 2nd Ed., Cambridge University Press, 1998.
3. L. Rossi, P. Fischer, T. Rohe and N. Wermes, Pixel Detectors: From Fundamentals to Applications (Particle Acceleration and Detection), Springer, 2006.

Teaching Learning Strategies

1. Class room Lectures
2. Presentations to show the applications of detectors
3. Activities

Assignments: Types and Number with Calendar

1. Problem set 1
2. Problem set 2
3. Quiz 1
4. Quiz 2

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

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Course Title	Data Analysis Techniques in High Energy Physics (3 credits)
Course Code	PHYS 5324
Credit Hours	3 Cr
Pre- requisites	Computational Physics, Numarical Analysis
Learning outcomes	On completion of this course, the students will be able • To Analyze and fit the data also extract the physics of high energy experiment.
Contents	Real-time triggering and filtering: Definitions and goals of triggers and filters, Trigger schemes, Queuing theory, queuing simulation and reliability, Classification of triggers, Examples of triggers, Implementation of triggers, Multiprogramming, Communication lines, bus systems, Pattern recognition: Foundations of track finding, Principles of pattern recognition, Basic aspects of track finding, Methods of track finding, Finding particle showers, Track and vertex fitting: The task of track fitting, Estimation of track parameters, Fitting the tracks of charged particles, Association of tracks to vertices, Track reconstruction, Tools and concepts for data analysis (Using ROOT): Data access methods, Multidimensional analysis, Data selection, Data accumulation, projection and presentation
Teaching-learning Strategies	Class room teaching/lecturering, practical
Assignments-Types and Number	Problem sheets, 3-4
Assessment and Examinations	Mid-Term Assessment: 35% Formative Assessment: (25%): It includes classroom participation, attendance, assignments and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc. Final Term Assessment: 40%
Text Books	Recommended Books: 1. R. Frühwirth, M. Regler, R. K. Bock, H. Grote and D. Notz (Author), Data Analysis Techniques for High-Energy Physics, 2 nd Ed., Camberidge University Press, 2000. 2. R K Bock, H Grote, D Notz, Data Analysis Techniques for High-Energy Physics Experiments, Cambridge University Press, 2010 3. S. Brandt, Data Analysis, 3 rd Ed., Springer, 1999.