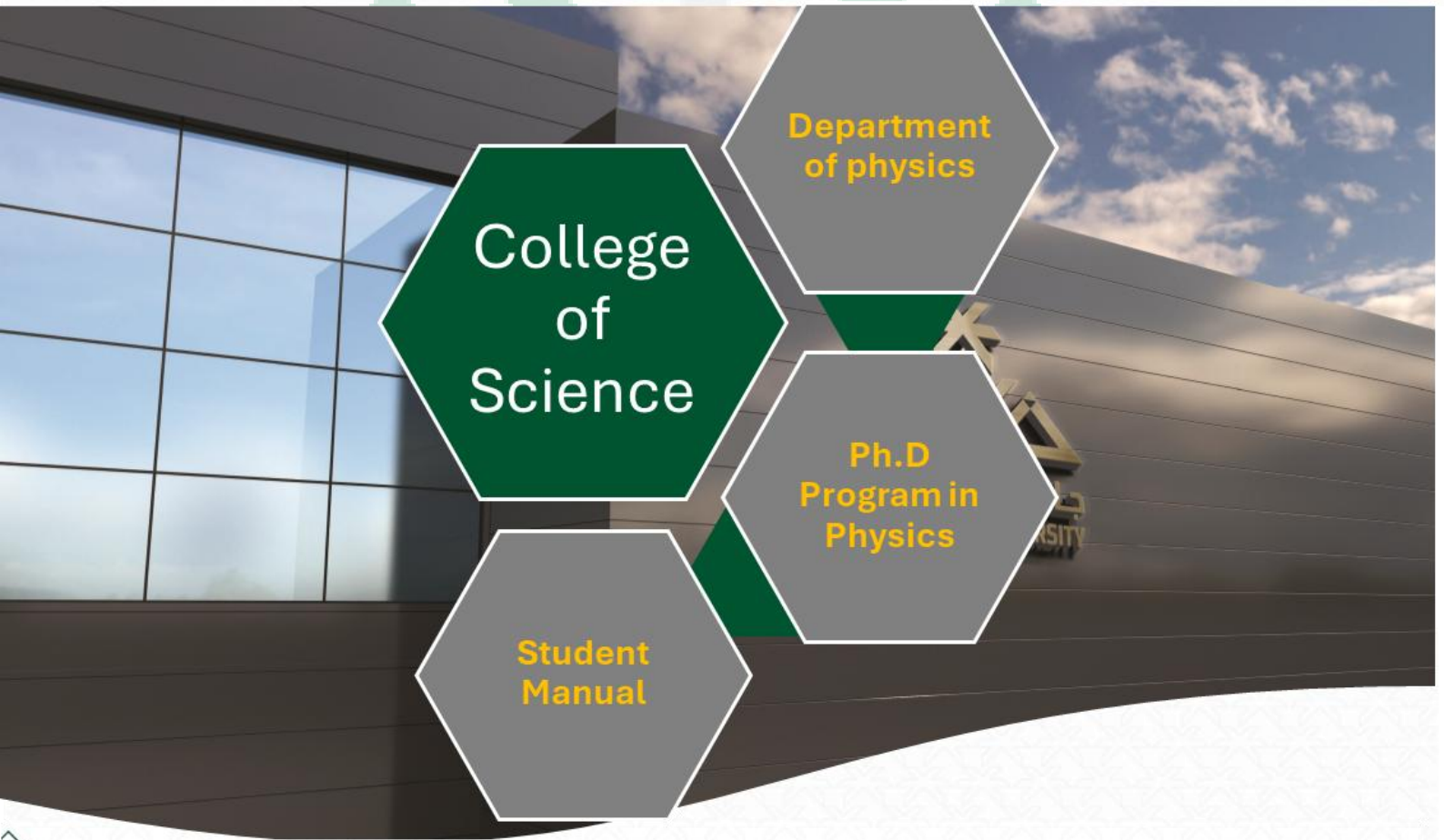
جامعة الملك خالد
KING KHALID UNIVERSITY



# Ph.D. Program at the Department of Physics

## College of Science- King Khalid University

**Contents:**

# Program Cover Letter

The Department of Physics is one of the most active departments at King Khalid University and is always at the forefront when it comes to publishing research in the most prestigious and high impact factor scientific journals. Currently, the department encompasses a plethora of distinguished professors from the Kingdom of Saudi Arabia and their colleagues from all over the world who have completed their graduate studies and practiced their research and teaching activities in the finest universities and research centres in both male and female sections of the department. The University provides the department with the most recent scientific and computer equipment to enable faculty members to carry out their research tasks to the fullest.

Currently our department offers two programs, one for bachelor's degree and the other for master's degree. Both programs have contributed to the preparation of outstanding graduate students over the past two decades. Indeed, more than ninety students have obtained their master's degrees from the department. Most of these graduate students have attended or are currently attending the best international universities to obtain their Ph.D. degree while some of them have pursued their doctoral studies at some universities in the Kingdom. Recently, the department has received many requests and feedback from students expressing their desires and intentions to pursue their doctoral studies locally at our department.

The Department of Physics at King Khalid University has realized the urgency and the need for such important program, and it will make the difference. We, therefore, believe that the current time is convenient to develop and initiate a doctoral program. The availability of human resources and their expertise in various advanced research activities will help in achieving the desired goal of students, who have obtained their master's degree and wish to pursue their studies towards obtaining their Ph.D. degrees from the Department of Physics at King Khalid University.

# Introduction

The Department of Physics at King Khalid University considers the doctoral program as one of the bases for scientific research and development. The department supports the doctoral program with a distinguished group of professors and an advanced set of laboratories. The department also receives considerable financial and administrative support from the university administration.

We are looking forward to attracting a group of young graduate students and researchers who have master's degree to share the challenges and experience of scientific research and to explore new horizons in physics through their doctoral research and studies. We believe this opportunity can enrich the on-going research activities in the department and at the same time it will lead to increasing the number of publications of the department in a great deal and thus in its turn will eventually results in enhancing the overall worldwide ranking of King Khalid University to be among the best research universities.

Currently our department is pursuing research in many directions that cover various interesting and promising areas of exploration, discovery, and innovation in different Physics disciplines. The Department lends all its potentials to achieve the objectives of Vision 2030 and to participate in the scientific renaissance of the Kingdom.

# Program Name and the Degree It Offers

Program name: Ph.D. program in Physics.

Degree offered by the program: Ph.D. in Physics.

The program specification for PhD program in physics can be found at the following link below:

**Click here for: Program specification**

# Mission, and Objectives

## Mission:

The mission is to conduct advanced and internationally recognised research in various fields of applied and theoretical physics to prepare qualified scholars who contribute to scientific research, sustainable community services and development.

**Click here for: Mission**

## Objectives:

- Acquire a rigorous advanced knowledge and a firm understanding of physics.
- Develop required skills to conduct independent research in physics and become leader in the chosen career.
- Foster abilities to identify, formulate, and solve challenging scientific and technical problems encountered in physics academic, research, and industry fields.
- Gain proficiency in reading the scientific literature and in communicating scientific findings in both oral and written forms.
- Demonstrate original and profound contributions to knowledge in the related physics disciplines.
- Extend expertise, competence, knowledge, laboratory experience, training, and critical thinking to post graduate students to prepare them for advanced study and research in physics and/or for employment.
- Participate in the realisation of national development plans and the objectives outlined in the Kingdom's vision 2030.

**Click here for: Objectives**

# Program Learning Outcomes

## Knowledge and Understanding:

At this level, the PhD graduates will have:

- K1 A deep-specialized knowledge and understanding structure in the field of specialization or work, integrating advanced information and specialized theories, principles and necessary concepts; creating new leading knowledge and involving the interaction of fields/specialties.
- K2 Accurate knowledge and understanding of processes, materials, techniques, practices and/or various terms associated with the field of specialty.
- K3 Comprehensive knowledge and understanding of the latest developments, issues, and emerging challenges in one or more fields of specialization and practices.
- K4 Advanced knowledge of conducting original research and scientific activities that contribute to the development of the field of specialization.

## Skills:

At this level, the graduate will have a set of cognitive, practical, and physical skills, as well as advanced and highly developed communication and information technology skills, to do the following:

- S1 Applying leading theories, concepts, and principles in highly complex contexts within the field of specialization and critically reviewing them, and creating original and innovative solutions for novel, challenging problems in one or more areas of practice, specialization or profession.
- S2 Solving problems in extremely complex contexts and developing sophisticated research methodologies and using them to produce new insights that contribute to the development of the field of specialization.
- S3 Utilizing advanced and modern processes, techniques, tools, devices, and/or materials in one or more specializations to carry out complex and innovative practical activities
- S4 Communicating in various ways to disseminate and enhance original knowledge and new perspectives and conducting scientific and professional dialogue with peers, specialized groups, and the community.
- S5 Implementing tools and applications of digital and communication technologies to promote and improve research and innovations in the field of specialization, professional practice, or work.

## Values, Autonomy, and Responsibility:

At this level, the graduate will be endowed with the following:

- V1 Maintaining the utmost integrity, adhering to core values, and upholding ethical standards in the professional and human context is essential when confronting and endorsing ethical challenges that arise in the realm of research and knowledge.
- V2 Continuously develop professional expertise and make strategic academic and/or professional decisions with very high independence, and effectively manage specialized tasks and activities in the field of specialization, work, or professional practice, with very high independence.

**Click here**

# Admission Requirements

Certain requirements should be satisfied in order to apply for admission of the Ph.D. program in Physics at King Khalid University:

A. General requirements stated in the Unified Regulations for Postgraduate Studies in Saudi Universities:

1. The applicant must be Saudi or have an official postgraduate scholarship for international students.
2. The applicant must have a master's degree from a recognized university with GPA "very good" at least.
3. The applicant must be of good conduct, physically, and mentally fit.
4. The applicant must arrange for three letters of recommendation from professors who have taught him/her at the Master level.
5. The applicant must be a Full-time Ph.D. student, and the University Council may exempt the student from this condition based on the recommendation of the department council.

The guidelines for completing the admission to PhD program can be found at the following link below:

**Click here for: The guidelines for completing the admission to PhD program**

The student can register for the PhD program using the following link.

**Click here to register for the PhD program**

B. Special requirements to check the language proficiency in English for the admission to PhD program in the Department of Physics at KKU can be found on the following link:

**Click here for: Special requirements to check the language proficiency**

1. The applicant must have passed one of the following English tests:

TOEFL with PBT 550 or TOEFL with IBT 80 or IELTS with 6 or equivalent. *

- * The applicant must have passed one of the following English tests (except those students who earned their master's degree from countries where English is the primary language)

2. The applicant must pass the admission exam, and/or the personal interview held by the department.

The department may require a student to take-up some M.Sc. courses based on the applicant's transcript.

C. Rules and Regulations Governing Full and Partial Scholarships for PhD program can be found on the following link:

**Click here for: Rules and Regulations**

**D. Guides for Academic Procedures**

The guide for the full academic study plans and procedures can be found at the following link.

**Click here for: Procedures**

**Click here for: Study Plan**

**E. Graduate Studies Regulations**

The several regulations related to graduate studies are listed below:

- The Regulations Governing Graduate Studies in Universities and Their Implementing Rules at King Khalid University
- Regulations Governing Tuition-Based Graduate Programs
- Regulations Governing the Scientific Publication Requirement for Doctoral Dissertation Defense
- Study and Examination Regulations for the Undergraduate Stage and Their Implementing Rules at King Khalid University – 1447 AH
- Regulations Governing the Scientific Publication Requirement for Doctoral Dissertation Defense

All these regulations can be found at the following link:

**Click here for: Regulations**

**F. Graduate Studies Forms**

The several forms pertaining to graduate studies are listed below:

i. Forms Related to research plan
ii. Forms related to thesis and dissertation defense
iii. Forms related to the establishment and development of graduate programs
iv. Forms related to student's academic procedures

All documents can be found at the following link:

**Click here for: Graduate Studies Forms**

# Sub-specialties

The Department of Physics at King Khalid University is currently pursuing research in four areas, representing the basic sub-specialties of physics. For Ph.D. studies, the students may choose any one of the following sub-specialties:

1. Condensed Matter Physics (CMP).
2. Atomic, Molecular and Optical Physics (AMOP).
3. Nuclear and Particle Physics (NPP).
4. Plasma and Fluid Physics (PFP).

The student may request a faculty member to supervise his/her dissertation after completion of the physics research seminar during the first semester.

# Doctoral Degree Requirements

In order to obtain a Ph.D. degree from the Department of Physics, King Khalid University, student must:

1. Pass the compulsory and the optional courses required by the department (21 hours).
2. A minimum of 75% attendance is mandatory to appear in the final exam for all courses.
3. Pass physics research seminar and lab safety courses (each course carries 1 contact hour and 0 credit hour).
4. Pass the comprehensive exam in physics held by the department.
5. Perform as a teaching assistant in labs and problem-solving sessions at least for one semester in accordance with university regulations.
6. Pass the dissertation defense held by the department to discuss the doctoral dissertation prepared by the student.
7. Attend one international/local conference and publish at least two articles in ISI journals.

# Student Support System

The Department of physics is committed to supporting and enhancing the well-being and success of our Ph.D. students as following:

- The department council assign an academic advisor to each Ph.D. student based on the field of specialization and the recommendation of the committee of higher studies. Academic

advisors should assess and help the student in all academic affairs such as course registration and providing mentorship in ethics and other forms of creative activity.

- Physics department often organizes lab safety training, workshops, seminars, and computational physics training programs.
- The university offers merit-based scholarships, international student scholarships and research project grants in addition to travel grants to attend national conferences, workshops and summer schools.
- Scientific club is approved by the department council each year and that supports students by organizing and promoting student activities (sports, social, cultural, etc.) through student committees.
- Promoting academic guidance and the role of the academic advisor in helping students plan for their research work.

## Student's Rights, Responsibilities and Complaint Procedure

To maintain a productive academic environment, students are granted specific rights and are expected to fulfil certain responsibilities. Universities also establish complaint and grievance procedures to ensure fairness, transparency, and academic integrity.

- Students have the right to access qualified academic advisors and to explore research topics within approved academic framework.
- Students are entitled to access the research lab facilities, libraries, softwares, funding opportunities and academic resources.
- Students must conduct honest research and avoid data plagiarism and data fabrication.
- Students should follow approved research methodologies and comply with lab safety regulations.
- Student must follow professional conduct, respect faculty members, follow departmental regulations and maintain regular communications with academic and scientific supervisors.
- In case of any complaint or grievances, students are encouraged to first discuss with supervisor seeking mediation through the program coordinator or head of the department.
- If informal resolution fails, student may submit a written complaint to the department chair, program coordinator or dean of the college.

## Courses

In order to obtain a Ph.D. from the Department of Physics at King Khalid University, the student must pass 7 courses (21 credit hours) in four semesters (levels). Four courses are compulsory, and three courses are optional. The student must also pass Physics Research Seminar (7000-Phys) and Lab Safety (Sci ***) courses (each course 1 contact hour and 0 credit hour). The department may require a student to take some M.Sc. courses based on his/her performance during the Ph.D. program. All credit and non-credit courses are designed to help the students to conduct their research and to

prepare their dissertation. These courses will also help the graduates of the program in their professional careers either as educators or researchers.

The following table shows courses which students will be taking during the first four levels.

| | |
|---|---|
| **1st Level**<br>7000-Phys Physics Research Seminar<br>7001-Phys Advanced quantum Mechanics<br>7002-Phys Advanced Electrodynamics | **2nd Level**<br>Sci*** Lab Safety (7004Phys)<br>Advanced Statistical Physics (7006Phys)<br>Compulsory Specialized Course |
| **3rd Level**<br>2 Optional Specialized courses | **4th Level**<br>Comprehensive Examination (7500Phys)<br>Advanced Research Topics (7501Phys)<br>PhD Dissertation (7600Phys) |

The following table shows information about course titles, codes, hours, types, and levels.
CC. = Compulsory Course
OP. = Optional
CMP = Condensed Matter Physics
AMOP = Atomic, Molecular, and Optical Physics
NPP = Nuclear and Particle Physics
PFP = Plasma and Fluid Physics
c = class lecture, p = practice, l = lab

| Course Title | Code | Credit (c+p+l) | Contact (c+p+l) | Type | Level |
|---|---|---|---|---|---|
| Physics Research Seminar | 7000 Phys-1 | (0+0+0) | (1+0+0) | CC. Phys | **1** |
| Advanced Quantum Mechanics | 7001 Phys-3 | (3+0+0) | (3+0+0) | CC. Phys | **1** |
| Advanced Electrodynamics | 7002 Phys-3 | (3+0+0) | (3+0+0) | CC. Phys | **1** |
| Lab Safety | 7004 Phys-1 | (0+0+0) | (1+0+0) | CC. Sci | **2** |
| Advanced Statistical Physics | 7003 Phys-3 | (3+0+0) | (3+0+0) | CC. Phys | **2** |
| Advanced Condensed Matter Physics | 7101 Phys-3 | (3+0+0) | (3+0+0) | CC. CMP | **2** |
| Advanced Nuclear Physics | 7201 Phys-3 | (3+0+0) | (3+0+0) | CC. NPP | **2** |
| Physics of Atoms and Molecules | 7301 Phys-3 | (3+0+0) | (3+0+0) | CC. AMOP | **2** |
| Plasma Physics | 7401 Phys-3 | (3+0+0) | (3+0+0) | CC. PFP | **2** |
| Fluid Mechanics | 7402 Phys-3 | (3+0+0) | (3+0+0) | CC. PFP | **2** |

| | | | | | |
|---|---|---|---|---|---|
| Advanced Semiconductors | 7102 Phys-3 | (3+0+0) | (3+0+0) | OP. CMP | **3** |
| Surface Physics and Interface | 7103 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Optoelectronics | 7104 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Physics of Nanomaterials | 7105 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Physics of Crystalline State | 7106 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Physics of Composite Materials | 7107 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Biophysics | 7108 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Computational Physics | 7109 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Group Theory | 7110 Phys-3 | (3+0+0) | (3+0+0) | OP.CMP | **3** |
| Selected Topics in CMP | 7111 Phys-3 | (2+1+0) | (2+1+0) | OP. CMP | **3** |
| | | | | | |
| Nuclear Reactions | 7202 Phys-3 | (3+0+0) | (3+0+0) | OP. NPP | **3** |
| Radiation Physics and Detectors | 7203 Phys-3 | (3+0+0) | (3+0+0) | OP. NPP | **3** |
| Relativistic QM and QFT | 7204 Phys-3 | (3+0+0) | (3+0+0) | OP. NPP | **3** |
| Nuclear Forces and Nuclear Structure | 7205 Phys-3 | (3+0+0) | (3+0+0) | OP. NPP | **3** |
| Radiation Protection | 7206 Phys-3 | (3+0+0) | (3+0+0) | OP. NPP | **3** |
| High Energy Physics | 7207 Phys-3 | (3+0+0) | (3+0+0) | OP. NPP | **3** |
| Selected Topics in NPP | 7208 Phys-3 | (2+1+0) | (2+1+0) | OP. NPP | **3** |
| Atomic and Optical Physics | 7302 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Advanced Atomic and Molecular Structure | 7303 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Scattering Theory | 7304 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |

| | | | | | |
|---|---|---|---|---|---|
| | Phys-3 | | | | |
| Nonlinear Optics | 7305 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Advanced Quantum Optics | 7306 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Laser Spectroscopy | 7307 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Laser-Matter Interaction | 7308 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Ultra-Fast Lasers and Photonics | 7309 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Introduction to Quantum Computation and Quantum Information | 7310 Phys-3 | (3+0+0) | (3+0+0) | OP. AMOP | **3** |
| Selected Topics in AMOP | 7311 Phys-3 | (2+1+0) | (2+1+0) | OP. AMOP | **3** |
| Advanced Plasma Physics | 7403 Phys-3 | (3+0+0) | (3+0+0) | OP. PFP | **3** |
| Advanced Fluid Mechanics | 7404 Phys-3 | (3+0+0) | (3+0+0) | OP. PFP | **3** |
| Magnetohydrodynamics | 7405 Phys-3 | (3+0+0) | (3+0+0) | OP. PFP | **3** |
| Selected Topics in PFP | 7406 Phys-3 | (2+1+0) | (2+1+0) | OP. PFP | **3** |
| | | | | | |
| Comprehensive Examination | 7500-Phys | (0+0+0) | (0+0+0) | CC. | **4** |
| Advanced Research Topics | 7501-Phys | (0+1+2) | (0+1+4) | OP. | **4** |
| | | | | | |
| Dissertation** | 7600-Phys | (0+3+6) | (0+3+6) | CC. | **5** |

**The total number of hours appearing in the student's transcript should reflect contact hours and accumulative hours of dissertation over semesters (accumulative dissertation contact hours = 9 × number of semesters).

# Comprehensive Examination

The comprehensive exam is one of the compulsory requirements to obtain the Ph.D. degree in physics at King Khalid University. All Students are required to satisfactorily pass the Ph.D. Comprehensive Examination that consists of two parts – written exam (which is fulfilled through a series of Subject Exams) and an oral exam in the field of specialization.

1. The written examination consists of four separate parts. These parts cover Advanced Classical Mechanics, Electrodynamics, Quantum Mechanics, and Statistical Mechanics. The weights of these four papers are equal. The written comprehensive exam shall be held once in an academic year during the second semester. However, the department may hold the exam twice a year in case of necessity.

2. The oral examination part will be in the student's field of specialization in which the student will deliver an oral presentation related to his/her dissertation before an examination committee, consisting of at least three members in the same field including the dissertation supervisor.

The student must register for the comprehensive examination both written and oral before registration for dissertation.

The following rules are related to the comprehensive exam:

1. The number of allowed attempts for the written comprehensive exam is two. If the student does not pass the written exam completely in the first attempt, he/she can apply to re-take the exam in the beginning of the following semester.

2. The grade of passing the comprehensive exam is 70% and the grade in each subject should not be less than 60%.

3. In case the student fails to pass the oral exam, he/she can apply to re-take the exam in the beginning of the following semester.

4. If the student fails to pass the Ph.D. comprehensive examination (written and/or oral parts) in the allowed attempts, he/she will be dismissed from the program.

The rules governing the Comprehensive Examination in the Doctoral Program can be found at the following link below:

**Click here for: The rules governing the Comprehensive Examination**

# Channel System

After taking the compulsory and optional courses and passing the comprehensive exam, a student may apply for a channel system. Through this channel system, the student may spend an extended period in a lab of an international university. The student may conduct part of his/her dissertation research under a joint supervision of his local physics advisor, and an advisor from the international university, who may be a member of the committee before which the student will defend his/her dissertation in accordance with university regulations.

# Dissertation

The student will write the doctoral dissertation in English and must be characterized by originality, innovation and active contribution to the development of knowledge in the student's field of specialization. The dissertation must be supervised by one of the professors or the associate professors in the department. The dissertation must be defended before a committee suggested by the advisor and approved by the department. This committee should include an external examiner.

Before registering for the dissertation, the student must prepare a proposal for his/her Ph.D. dissertation, defining the main research point including objectives, methodology, and expected outcomes. The proposal must be approved by the supervisor before submission to the department.

The department encourages students to apply for fund in different public and private funding agencies. Some of the funding agencies are given below:

1. Deanship of Scientific Research at King Khalid University.
2. Advanced Material Centre at King Khalid University.
3. King Abdul-Aziz City of Science and Technology KACST.
4. Research and Development Office RDO.

The regulations governing the supervision of Graduate Theses and Dissertations can be found at the following link below:

**Click here for: The regulations governing the supervision of Graduate Theses and Dissertations**

# Scientific Publication Regulations

Scientific Publication Regulations for Graduate Students

A Prerequisite for Doctoral Dissertation Défense

1. The requirement for scientific publication is limited to the doctoral dissertation defense.
2. These regulations apply to students admitted in the academic year 1439/1440 AH and thereafter.

3. Students may publish their work through journals and publication outlets classified by the Scientific Council:
(https://ssc.kku.edu.sa) and (https://scs.kku.edu.sa), scientific conferences, seminars, and scientific journals issued by official government entities in the Kingdom of Saudi Arabia, provided that all publication outlets are peer-reviewed and specialized.
4. Approval for student publication (whether the research is published or accepted for publication) is granted by the academic department or college, and the application is submitted to the Deanship of Graduate Studies.
5. The research is credited to the student whether conducted independently or in collaboration with the supervisor, and it must be derived from the doctoral dissertation or from outside of it.
6. The research papers submitted as a requirement for admission to the program are not considered for discussion.
7. The publication date must be during the student's doctoral studies.
8. The student must list King Khalid University as their affiliation in the publication where the research is published.
9. The publication must be in the student's field of specialization within the doctoral program.

# Academic Integrity and Citation Guidelines

Academic integrity is a fundamental principle that underpins all scholarly activities within the PhD Program in Physics at King Khalid University. It reflects a commitment to honesty, transparency, and ethical conduct in research, teaching, and publication. Upholding academic integrity ensures the credibility of scientific contributions and reinforces the University's role in advancing knowledge at both national and international levels.

Doctoral candidates are expected to adhere strictly to ethical standards in all aspects of their academic work. This includes accurate representation of data, proper acknowledgment of others' contributions, and avoidance of all forms of academic misconduct, such as plagiarism, data fabrication, falsification, and duplicate publication. In the field of physics, where research often builds cumulatively on prior discoveries, maintaining integrity in citation and attribution is essential to preserving the reliability and reproducibility of scientific findings.

Proper citation practices are a critical component of academic integrity. Students must consistently apply recognized citation styles appropriate to the discipline—such as APA, IEEE, or journal-specific formats—ensuring that all sources of information, ideas, data, and methodologies are clearly and accurately referenced. This includes published articles, conference proceedings, datasets, software tools, and any collaborative contributions. Failure to provide a proper citation not only undermines scholarly rigor but may also result in disciplinary action.

Furthermore, PhD candidates must ensure that all submitted research complies with King Khalid University's publication and affiliation guidelines, including clear attribution to the institution and adherence to international standards for peer-reviewed publication. The ethical use of sources,

combined with rigorous citation practices, enhances the quality, impact, and global recognition of the research produced within the program.

For more details, please refer to the links:

**Click here for: Guidelines for scientific research**

**Click here for: Scientific Research and Innovation Regulations**

**Click here for: Ethics of scientific research**

**Click here for: Academic Integrity and Intellectual Property Rights**

# Resources and Capabilities of the Physics Department

The Department of Physics at King Khalid University has a group of more than 50 distinguished faculty members. Their research interests are focused on various sub-specialties mentioned previously, as follows:

1. Condensed Matter Physics (CMP).
2. Atomic, Molecular and Optical Physics (AMOP).
3. Nuclear and Particle Physics (NPP).
4. Plasma and Fluid Physics (PFP).

The department has an advanced set of laboratories to carry out many experimental measurements necessary to conduct scientific research, including:

| | |
|---|---|
| **1** | Solid State Structure and Thermal Analysis Laboratory (SSSTAL) |
| **2** | Optical and Photoelectronic Measurements Laboratory (OPML) |
| **3** | Thin Films Deposition and Nanostructures Laboratory (TFDNL) |
| **4** | Advanced Functional Materials and Optoelectronics Laboratory (AFMOL) |
| **5** | Electrical Measurements Laboratory (EML) |
| **6** | Samples Preparation Laboratory (SPL) |
| **7** | Ultrafast Photonics and Laboratory (UPL) |

# KKU Ph.D Course brief descriptions

## Physics Research Seminar (7000-Phys)

Credit hours: 0 (0+0+0) Level: 1 /Year: 1

**Course Description:**

In this course, a series of lectures will be delivered by faculty members who will give details about their research, labs, fund. After this course, a student may approach a faculty member requesting supervising his/her Ph.D. Dissertation.

**List of Required Textbooks**

Not Applicable

## Advanced Quantum Mechanics (7001-Phys)

Credit hours: 3 (3+0+0) Level: 1 /Year: 1

**Course Description:**

Nonrelativistic Many-Particle System: Second Quantization, Fermions, Bosons, Correlation Functions, Scattering, and Response. Relativistic Wave Equations: Klein–Gordon Equation, Dirac Equation, Covariance of Relativistic Wave Equations, Symmetries of Relativistic Wave Equations. Relativistic Fields: Quantization of the Radiation Field, Quantum Electrodynamics

**List of Required Textbooks**

1. Advanced Quantum Mechanics, by Franz Schwabl, Springer; 4$^{th}$edition (2008).

## Advanced Electrodynamics (7002-Phys)

Credit hours: 3 (3+0+0) Level: 1 /Year: 1

**Course Description:**

This course covers the advanced concepts and mathematical skills required to understand the propagation of electromagnetic waves at the interface between two mediums and provides a good knowledge of boundary-value problems. It also covers the theory of guided waves (TE and TM modes) in resonant cavities and optical fibres. Applications that are covered include charged particles in electromagnetic fields, radiation by moving charges, and scattering and diffraction of radiation. Special relativity is reviewed. The relativistic covariance of electrodynamics and the pertinent conservation laws are developed.

**List of Required Textbooks**

1. John David Jackson- Classical Electrodynamics, 3$^{rd}$ Edition, Wiley 2021.

2. D. J. Griffiths, Introduction to electrodynamics, 4th Edition, Benjamin Cummings 2017.

## Advanced Statistical Physics (7003-Phys)

Credit hours: 3 (3+0+0) Level: 2 /Year: 1

**Course Description:**

After strengthening the understanding of particle statistical physics (classic or quantum-ideal or interacting particles) by focusing on applications this course open the door for more advanced topics in statistical physics such as field's statistical physics, dissipative dynamics and stochastic process, out of equilibrium and complex system statistics.

**List of Required Textbooks**

1. 1. L. D. Landau and E. M. Lifshitz - Statistical Physics, Vol. 5, 3rd Edition, Butterworth-Heinemann, 2013
2. Kardar, M. (2007). Statistical physics of fields. Cambridge University Press.

## Laboratory Safety (7004-Phys)

Credit hours: 1 (1+0+0) Level: 2 /Year: 1

**Course Description:**

This course is based on basic safety measures and basic standards in a laboratory at the university level. To enhance the knowledge of students to effectively practice the health and safety regulations in laboratories. In addition, students will develop their skills in daily practice related to health and safety in the laboratory. Moreover, students will be trained in real laboratory situations and how to react and respond to such situations.

**List of Required Textbooks**

1. Koradecka, D. (Ed.). (2010). Handbook of occupational safety and health. CRC Press

## Advanced Condensed Matter Physics (7101-Phys)

Credit hours: 3 (3+0+0) Level: 2 /Year: 1

**Course Description:**

This course introduces quantum field theoretical methods aimed at both experimentalists and theorists, with a particular focus on condensed matter physics (CMP). The content spans a wide range of topics necessary for understanding concepts and methods utilized in the modern subjects of advanced CMP.

**List of Required Textbooks**

1. Marder, M. P. (2010). Condensed matter physics. John Wiley & Sons.
2. A. Altland and B. Simons, Condensed Matter Field Theory, Cambridge University Press, 2006.
3. G. D. Mahan, Many-Particle Physics, Springer, 2010.

## Advanced Nuclear Physics (7201-Phys)

Credit hours: 3 (3+0+0) Level: 2 /Year: 1

**Course Description:**

The course is the first advanced course in the direction of subatomic physics. The course is based on an introductory course in nuclear physics and is intended to give a deeper insight into the physics of the atomic nucleus and a brief introduction to particle physics. Treated subjects are models of the nucleus, decay processes, and nuclear reactions. Applications to nuclear science will be used to illustrate these principles.

**List of Required Textbooks**

1. Lilley, J. (2013). Nuclear physics: principles and applications. John Wiley & Sons
2. Krane K.S. Nuclear Physics, Wiley India Pvt. Ltd., (2008).

## Physics of Atoms and Molecules (7301-Phys)

Credit hours: 3 (3+0+0) Level: 2 /Year: 1

**Course Description:**

This course gives advanced knowledge of the structure of atoms and molecules and their interactions with electromagnetic radiation. The course also illustrates the role of quantum mechanics as the fundamental theory for the description of the microscopic world.

**List of Required Textbooks**

1. B. H. Bransden, Charles Jean Joachain, Physics of atoms and Molecules, Prentice Hall, 2003.

## Plasma Physics (7401-Phys)

Credit hours: 3 (3+0+0) Level: 2 /Year: 1

**Course Description:**

This course will focus on the following topics: Introduction to plasma physics, Single-Particle Motions, Plasmas as Fluids, Waves in plasmas, Diffusion and Resistivity

**List of Required Textbooks**

1. Chen F. (2015) Introduction to Plasma Physics and Controlled Fusion, Springer.

## Fluid Mechanics (7402-Phys)

Credit hours: 3 (3+0+0) Level: 2 /Year: 1

**Course Description:**

The course comprehensively explores the fundamental principles of fluid mechanics, emphasizing the critical concepts essential for understanding fluid behaviour. It begins with an introduction to fluid statics, examining the forces acting on fluids at rest, followed by an analysis of fluid kinematics, including velocity and acceleration fields. The dynamics of fluid motion are then discussed, focusing on the conservation laws that govern fluid behaviour, such as mass, momentum, and energy. The course further delves into the viscous flow, highlighting the effects of viscosity on fluid movement, and concludes with an examination of compressible flow, addressing the behaviour of fluids under varying pressure and temperature conditions. This structured approach ensures a solid foundation in fluid mechanics, facilitating the application of these principles in various contexts.

**List of Required Textbooks**


1. Munson, B. R., Okiishi, T. H., Huebsch, W. W., & Rothmayer, A. P. (2013). Fluid mechanics (pp. 271-274). Singapore: Wiley.
2. John F. Douglas, Janusz M. Gasiorek, Fluid Mechanics, Fifth Edition, 2006.


## Advanced Semiconductors (7102-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course provides an in-depth exploration of semiconductor physics, focusing on the fundamental principles and advanced concepts that underpin semiconductor materials and their applications in modern technology. Topics include carrier behaviour in both equilibrium and non-equilibrium states, the influence of dopants, and the transport phenomena essential to device functionality. Through a study of photoconductivity and photovoltaic materials, the course also addresses the critical role of semiconductors in optoelectronic and renewable energy applications

**List of Required Textbooks**


1. Neamen, D. A., & Biswas, D. (2011). Semiconductor physics and devices (pp. 106-169). New York: McGraw-Hill higher education.

2. S. M. SZE, M. K. LEE, Semiconductor Devices Physics and Technology, 3rd edition, John Wiley & Sons, Inc 2012.


## Surface Physics and Interface (7103-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

The standard PhD program in physics at King Khalid University includes courses on solid-state physics, Quantum Mechanics, and Atomic and Molecular Spectroscopy. Providing material on such

diverse topics is a difficult task partly because of the huge amount of material and partly because of the different nature of concepts used in these branches of physics.

The scope of the present course may be gauged from the Contents. Each chapter consists of a succinct presentation of the physical principles, followed by a large number of completely solved problems which are a valuable learning tool and naturally develop the subject and illustrate these principles. Hence, the general description of the corresponding course is:

• Overview of research and research methodologies: significance of research, concepts of research, quality of research and types of research

• Carrying out a literature review on the research topics of the PhD dissertation.

• Adopting and defining research problems: formulation, criteria for selecting a problem, identifying variables, evaluating problems, and hypothesis functions.

• Managing a research project: designing achievable plans, collection of materials, writing progress, and final report

**List of Required Textbooks**

1. Kothari, C. R. (2017). research methodology methods and techniques by CR Kothari. Published by New Age International (P) Ltd., Publishers, 91.

2. Research Methodology by Chris Welman, Fanie Kruger, Bruce Mitchell, Oxford University Press, 2005.

**Optoelectronics (7104-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course starts with the fundamental concepts of electronic transport and optical properties of semiconductors, junctions including homo-junctions and hetero-junctions, metal-semiconductor junctions, and metal-insulator-semiconductor junctions in equilibrium. This course also includes the principles and technology of modern optoelectronic devices such as photodetectors, solar cells, light detectors, and laser diodes.

**List of Required Textbooks**

1. Donald A. Neamen, Semiconductor Physics and Devices, McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 2012

2. Micro-and Optoelectronic Materials and Structures: Physics, Mechanics, Design, Reliability, Packaging, Vol 1 and 2, Editors: E. Suhir, Y.C. Lee, C. P. Wong, Springer Science+Bisness Media. Inc. 2007

**Physics of Nanomaterials (7105-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course is intended to provide a guide to the ideas and physical concepts that allow an understanding of the changes that occur as the size scale shrinks toward the atomic scale. This course includes a general introduction to the concepts of nanophysics, which will greatly improve the ability of students and professionals whose undergraduate training has been in engineering or applied science to contribute to the various areas of nanotechnology. The broadly applicable concepts of nanophysics are worth studying, as they do not become obsolete with inevitable changes at the forefront of technology.

**List of Required Textbooks**

1. Gusev, A. I., & Rempel′, A. A. (2004). Nanocrystalline materials. Cambridge Int Science Publishing.

2. Nanophysics and Nanotechnology Edward L. Wolf 2004 Wiley-Vch Verlag GmbH & Co. KGaA

**Physics of Crystalline State (7106-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This current course will spotlight an overview of the physics of crystalline materials, especially single crystals, and the growth techniques involved. Concept of nucleation, Principles of Crystal growth, Super Saturation, Nucleation, rate of crystallization, fractional crystallization, crystal growth, types of crystallization. Relation of crystalline structure with properties like density, melting point, boiling point, and solubility. Atoms in crystals, atomic bonding, Atomic packing, shape, and size, Crystal imperfection, atomic diffusion and Lattice vibrations. Diffraction of waves and particles by crystal.

Crystal growth techniques:

1. Solution technique: slow evaporation and Sankaranarayan-Ramasamy (SR) method
2. Slow cooling technique
3. Vertical Gradient Freezing (VGF) technique
4. Bridgeman-Stockbarger technique (VBT)
5. Czochralski (Cz) technique

Characterization methods for crystalline materials, Optical, dielectric, magnetic, superconductivity, thermal properties of crystalline materials, Anisotropic properties of crystalline materials

**List of Required Textbooks**

1. Phillips, P. (2012). Advanced solid state physics. Cambridge University Press
2. Wahab, M. A. (2005). Solid state physics: structure and properties of materials. Alpha Science Int'l Ltd

## Physics of Composite Materials (7107-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course will go over the latest innovations in materials science and their practical applications, emphasizing glass and its unique photonics characteristics. Glass has several structural and practical benefits over crystalline materials. These include the ability to be doped with a variety of elements, a wide range of sizes and shapes, and exceptional uniformity. It is widely believed that glasses exhibiting photonic capabilities will play a pivotal role in future multimedia systems. We cover the basics of glass and go on to teach about gradient index glass, laser glasses, non-linear optical glasses, and magneto-optical glasses.

**List of Required Textbooks**

1. Bruce, D. W., O'Hare, D., & Walton, R. I. (Eds.). (2011). *Functional oxides*. John Wiley & Sons
2. Yamane, M., & Asahara, Y. (2000). *Glasses for photonics*. Cambridge University Press.

## Biophysics (7108-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2



**Course Description:**

Fundamentals of biophysics, Structural Biology, Spectroscopy and Microscopy, Computational Biophysics and Bioinformatics, and Biophysical Chemistry. The main focus is to offer research training in the applications of physics-based techniques to biological systems ranging in complexity from single molecules to whole cells and tissues. The coursework is flexible and is designed to allow students to take exciting classes in the field of specialization while providing the fundamental background knowledge necessary for putting this specialization in a broader context.

To learn about the dynamical Processes in Biophysics, Physics of Complexity, Engineering Fundamentals in Biological Systems, Biophysical Principles of Microscopy

To understand the structural biology such as: Advanced X-ray crystallography, Multi-dimensional NMR spectroscopy, Survey in Bioinformatics, Dynamical Processes in Biophysics, Signal Transduction, Molecular Biology

To learn about computational biophysics as follows: Survey in Bioinformatics, Introduction to Artificial Intelligence, Numerical Methods for Scientific Computing, Topics in Molecular Evolution, Discrete State Stochastic Processes, Statistical Models and Numerical Methods in Human Genetics

**List of Required Textbooks**


1. Bialek, W. (2012). *Biophysics: searching for principles*. Princeton University Press.
2. Lindsay, S. (2003). Biophysics: An Introduction by Rodney Cotterill. *AMERICAN JOURNAL OF PHYSICS*, *71*(11), 1214-1214.


**Computational Physics (7109-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

The course mainly includes an introduction to computational material science, Hartree Fock method, Density functional theory, Quantum Monte Carlo methods, Molecular dynamics simulation, Tight binding models and electronic structures.

**List of Required Textbooks**


1. 1. Thijssen, Jos. Computational physics. Cambridge university press, 2007.
2. 2. Harrison, Paul, and Alex Valavanis. Quantum wells, wires and dots: theoretical and computational physics of semiconductor nanostructures. John Wiley & Sons, 2016.


**Group Theory (7110-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2



**Course Description:**

Motivation for studying group theory and introduction to its basic structure

- Fundamental definitions and theorems of group theory and symmetries
- The theory of group representations
- Relationship of group theory to problems in physics
- Direct product theory
- Discrete groups and their applications

Molecular and crystallographic point groups, Space groups and applications to solid-state physics, Spatial-inversion and time-reversal symmetries, Continuous groups and their applications,

Fundamentals of Lie groups and Lie algebras, translation group in N dimensions: T(N), The rotation group in 2 and 3 dimensions: SO(2) and SO(3), The "special unitary group of degree 2": SU(2), Permutation (or symmetric) group of n objects: P(n)

**List of Required Textbooks**


1. 1. Dresselhaus, M. S., Dresselhaus, G., & Jorio, A. (2007). Group theory: application to the physics of condensed matter. Springer Science & Business Media.
2. 2. Jones, H. F. (2020). *Groups, representations and physics*. CRC Press.


## Selected Topics in Condensed Matter Physics (7111-Phys)

Credit hours: 3 (2+1+0) Level: 3 /Year: 2

**Course Description:**

This course tackles variety of selected topics in the field of condensed matter physics related to faculty expertise and student needs. Topics in this course should provide the students with extended knowledge of the subject adding to that covered by earlier courses.

**List of Required Textbooks**

Textbooks will depend on the topic selected

## Nuclear Reactions (7202-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

General Description of Nuclear Reactions , Direct Nuclear Reactions, Optical Model and Diffraction Phenomena, Introduction to physics of exotic nuclei and Radioactive Beams., Secondary beams of rare isotopes, Nucleus-nucleus scattering at high energies, Sizes and energies of exotic nuclei, Break-up reactions and momentum distributions, Borromean nuclei, Elastic and inelastic scattering, Nuclear astrophysics, Formation of heavy and super heavy elements.

**List of Required Textbooks**


1. "Physics of Radioactive Beams", C.A. Bertulani, M. Hussein and G. Muenzenberg, Nova Science, Hauppage, NY(2002)
2. "Nuclear Reactions for Astrophysics", Principles, Calculation and Applications of Low-Energy Reactions; Ian J. Thompson and Filomena M. Nunes. Cambridge University Press (2009)


## Radiation Physics and Detectors (7203-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

The course provides theoretical knowledge of the detection of ionizing radiation and a good knowledge of measurement techniques. It covers the measurement of small currents and charges, pulse height analysis, statistics, and corrections. Gas, scintillation, and semiconductor detectors, as well as neutron detectors, are treated. It also covers gamma spectroscopy, charged particle spectroscopy, and neutron spectroscopy.

**List of Required Textbooks**

1. Knoll, G. F. (2010), *Radiation detection and measurement*. John Wiley & Sons.

2. Tsoulfanidis, N., & Landsberger, S. (2021). *Measurement and detection of radiation*. CRC press

## Relativistic Quantum Mechanics and Quantum Field Theory (7204-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

Introduction to relativistic quantum mechanics. The Klein-Gordon equation. The Dirac equation. Introduction to relativistic quantum field theory. Covariant perturbation theory. Elementary processes of quantum electrodynamics. Introduction to regularization, renormalization, and radiative corrections.

**List of Required Textbooks**

1. Maiani, L., & Benhar, O. (2024). Relativistic quantum mechanics: an introduction to relativistic quantum fields. CRC Press

2. Peskin, M. E. (2018). An Introduction to quantum field theory. CRC press.

## Nuclear Forces and Nuclear Structure (7205-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2



**Course Description:**

This course provides a comprehensive exploration of nuclear physics, covering a wide range of fundamental topics. Students will delve into the laws of invariance, the boson field theory and phenomenological potentials, as well as the study of few-nucleon systems.

The course will also examine the theory of scattering, nucleon-nucleon scattering, and nuclear systematics and properties. Additionally, students will learn about nuclear models, nuclear decay, the optical model, and the behaviour of single-particle states in deformed nuclei. The course will also include studies of two-nucleon transfer reactions, allowing students to gain a deeper understanding of nuclear structure and dynamics.

Through a combination of lectures, problem-solving sessions, and hands-on laboratory experiments, students will develop a strong foundation in the principles and applications of nuclear physics. The

course aims to equip students with the knowledge and skills necessary to pursue further studies or research in this field, as well as to appreciate the importance of nuclear physics in various scientific and technological applications.

**List of Required Textbooks**

1. Introductory Nuclear Physics, P. E. Hodgson, E. Gadioli and E. Gadioli-Erba 1997, Reprinted 2003.

2. Introductory nuclear physics. Krane K.S. U.S.A.: Wiley, 1987.

## Radiation Protection (7206-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course provides instruction on the nature of radiation and radioactivity, the hazard and risk it presents, the necessary control measures, and the application and method of compliance with relevant radiation safety legislation.

**List of Required Textbooks**

1. James E. Martin, Physics for Radiation Protection, 2nd Ed., WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2006.
2. James E. Turner,Atoms, Radiation, and Radiation Protection, 3rd Ed., WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 1995.

## High Energy Physics (7207-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course provides an introduction to particle physics. Lorentz transformations. The Dirac equation and the Dirac field. Quantizing fields: QED. The weak interaction. The Weinberg–Salam electroweak theory for leptons. The theory of strong interactions: quantum chromodynamics. Neutrino masses and mixing.

**List of Required Textbooks**

1. Cottingham, W. N., & Greenwood, D. A. (2007). *An introduction to the standard model of particle physics*. Cambridge university press.

## Selected Topics in Nuclear and Particle Physics (7208-Phys)

Credit hours: 3 (2+1+0) Level: 3 /Year: 2

**Course Description:**
This course tackles variety of selected topics in the field of nuclear and particle physics. Topics in this course should provide the students with extended knowledge of the subject adding to that covered by earlier course. Topics will be selected based on the instructor and the student research direction.

**List of Required Textbooks**
Textbooks will depend on the topic selected.

## Atomic and Optical Physics (7302-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

Photon-atom interactions: basics and semiclassical approximations, The two-state systems: Resonance, Atoms—electronic structure, Helium atom, Fine structure and Lamb shift, Hyperfine structure; Magnetic fields, Atoms in electric fields, Interaction of an Atom with an Electro-Magnetic Field, Einstein's A and B coefficient, Saturation of transitions, Line shapes, Two-photon transitions. Atomic and Molecular Structure including the Doubly excited atoms, planetary atoms, Atoms in high electric and magnetic fields, Molecular spectroscopy close to the dissociation limit, Wave packets in Rydberg atoms and cover some experimental methods related to atomic optical physics.

**List of Required Textbooks**
1. Bransden, B. H., & Joachain, C. J. (2003). Physics of atoms and molecules. Pearson Education India.

## Advanced Atomic and Molecular Structure (7303-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course prepares the student for further studies in atomic and molecular physics and research in atomic and molecular physics. For more details, the syllabus of this course covers the following subjects: One-electron atoms: energy levels and wave functions; spin-orbit interaction; electronic transitions; electric dipole approximation; quantum numbers and selection rules; angular momenta and coupling schemes; radiation of higher order; radiation-less transitions. Approximations for the Schrödinger equation; Coulomb- and exchange integrals; ground state and excited states; wave functions and their symmetry; spectra. Many-electron atoms: Theoretical approximation schemes; LS-coupling; fine structures; jj-coupling; configuration mixing; spectra. Molecular symmetry and motion: Symmetry and symmetry operations; point groups; group theory; representations; analysis of molecular motions. Molecular quantum mechanics and beyond bonding, LCAO-MO-approximation, symmetry adapted molecular orbitals, electronic states and electron correlations, rotations and vibrations including symmetry analysis, potential curves, and transitions between different states. Molecular spectra: Rotational- and vibrational resolved spectroscopy; electron

spectra; Franck- Condon principle; interaction with electromagnetic radiation; semi-empirical calculation methods.

**List of Required Textbooks**


1. Cowan, R. D. (2023). The theory of atomic structure and spectra (Vol. 3). Univ of California Press.
2. Bransden, B. H., & Joachain, C. J. (2003). Physics of atoms and molecules. Pearson Education India.


**Scattering Theory (7304-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

Classical scattering theory (relative motion projectile and target- scattering angle and scattering cross section), Coordinate and momentum representations. Types of convergence of state vectors and operators on the Hilbert space, Formal time dependent theory of potential scattering; wave operators and Scattering operator (S operator)., Unitarity of S operator, conservation of energy, scattering amplitude and cross section, optical theorem, Scattering of two particles. Computational wave-packet method for time-dependent scattering theory, Time-independent scattering theory. Lippman-Schwinger (LS) equation for the transition operator., LS equation in coordinate and momentum representations, Partial-wave decomposition. K matrix formulation, Quadrature discretization of LS equations, Variational methods: variational principles, Separable expansions of two-particle transition operator. summation of Born-Neumann series, Time-independent formalism of multi-channel scattering for inelastic collisions, Matrix LS equations of multi-channel scattering, Many-particle scattering theory

**List of Required Textbooks**


1. Taylor, J. R. (2012). *Scattering theory: the quantum theory of nonrelativistic collisions*. Courier Corporation.

2. Friedrich, H. (2015). Internal Excitation, Inelastic Scattering. In *Scattering Theory* (pp. 137-184). Berlin, Heidelberg: Springer Berlin Heidelberg


**Nonlinear Optics (7305-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course essentially deals with light-matter interaction when the response of material is nonlinear. It introduces nonlinear optics from the perspective of nonlinear susceptibility, which determines the nonlinear polarization of the optical media. That thus leads to nonlinear phenomena related to the second- and third-order nonlinear susceptibilities. This course also offers a description of light propagation through nonlinear media using the nonlinear wave equation. Thus, the concept of phase machining is to be introduced, as its role in second and third harmonic generation, sum, and difference frequencies generation. This course also provides a Nonlinear refractive index, processes leading to

the nonlinear refractive index, properties and applications related to the nonlinear refractive index. It presents processes resulting from spatial and temporal intensity distribution during the propagation of intense laser beams, such as self-focusing, filamentation, self-phase modulation, and soliton. This course also covers nonlinear photoionization, avalanche, multiphoton absorption, and optical damage.

**List of Required Textbooks**


1. Boyd, R. W., Gaeta, A. L., & Giese, E. (2008). Nonlinear optics. In Springer handbook of atomic, molecular, and optical physics (pp. 1097-1110). Cham: Springer International Publishing.
2. Sutherland, R. L. (2003). Handbook of nonlinear optics. CRC press.


**Advanced Quantum Optics (7306-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

The course is prepared with advanced undergraduate and beginning graduate students in mind. The emphasis, throughout, is on theoretical aspects of the subject of quantum optics.

**List of Required Textbooks**


1. Gerry, C. C., & Knight, P. L. (2023). Introductory quantum optics. Cambridge university press.
2. Loudon, R., & Scully, M. O. (1974). The quantum theory of light. Physics Today, 27(8), 48-48.


**Laser Spectroscopy (7307-Phys)**

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course covers Principles of Laser Action, Interaction Between Light/Laser and Matter. Properties of Laser Radiation as Spectroscopic Light Source. Instrumentation for Detection of Optical signals and Time-Resolved Measurements. Laser Absorption Spectroscopy. Laser Induced-Fluorescence Spectroscopy (LIFS). Laser Induced-Breakdown Spectroscopy (LIBS). Raman Spectroscopy. Non-Linear Phenomena and Generation of Short/Ultrashort Pulses. Non-linear Spectroscopy. Time-Resolved and Ultra-fast Laser Spectroscopy. Special Applications of Laser Spectroscopy.

**List of Required Textbooks**


1. Di Bartolo, B., & Forte, O. (Eds.). (2006). Advances in spectroscopy for lasers and sensing (Vol. 231). Springer Science & Business Media
2. Svanberg, S. (2001). Atomic and Molecular Spectroscopy—Basic Aspects and Practical Applications, 3 (Edition Springer. Heidelberg, Berlin, New York.

## Laser-Matter Interaction (7308-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course offers a guide for students who want to do research in the area of photonics or atomic plasma physics. This advanced course gives an introduction to the interaction of laser light with matter including the basics of ultrafast and intense laser technology. Starting with the optical properties of a material in a non-excited state, absorption, heating, melting, cooling, and solidification processes and their dynamics will be described briefly. The mathematical treatment of laser-matter interaction is done by a classical as well as quantum approach. Applications topics may include materials processing, laser ablation, heat treatment and welding, micromachining, and biomedical applications as they relate to matter transformation.

**List of Required Textbooks**

1. Silfvast, W. T. (2004). *Laser fundamentals*. Cambridge university press.
2. Gamaly, E. G. (2011). *Femtosecond laser-matter interaction: theory, experiments and applications*. Jenny Stanford Publishing.

## Ultrafast Lasers and Photonics (7309-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

Characteristics of femtosecond light pulses. Methods of generating ultrashort laser pulses: Q-switching, Active mode-locking, Passive mode-locking. Examples of ultrashort lasers: Solid State lasers (Ti: Sapphire), Fiber lasers, quantum well lasers Linear pulse propagation. Dispersion compensation. Nonlinear pulse propagation. Second-order nonlinearities with ultrashort pulses. Relaxation oscillations. Ultrashort laser pulse duration measurements. Ultrafast measurements: Pump-probe scheme. Brief introduction on ultrafast THz science.

**List of Required Textbooks**

1. Diels, J. C., & Rudolph, W. (2006). Ultrashort laser pulse phenomena. Elsevier.
2. W. Kaiser, Ed., Ultrashort Laser Pulses: Generation and Applications, Springer-Verlag, Berlin, (1993).

## Quantum Computation and Quantum Information (7310-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course introduces the main ideas and techniques of Quantum Computation and Quantum Information (QCQI). The course of QCQI utilizes the main principles in the course of Quantum Optics to demonstrate possible applications in technology.

**List of Required Textbooks**

1. Barnett, S. M. (2014). Quantum retrodiction. In *Quantum Information and Coherence* (pp. 1-30). Cham: Springer International Publishing.

2. Nielsen, M. A., & Chuang, I. L. (2010). *Quantum computation and quantum information*. Cambridge university press.

## Selected Topics in Atomic, Molecular, and Optical Physics (7311-Phys)

Credit hours: 3 (2+1+0) Level: 3 /Year: 2

**Course Description:**

This course explores a diverse selection of topics in atomic, molecular, and optical physics, specifically tailored to match the expertise of faculty members and to address the academic and research interests of students. The material covered in this course is designed to broaden and enhance students' knowledge beyond what was introduced in earlier studies, providing them with an advanced understanding of these specialized areas in physics.

**List of Required Textbooks**

Textbooks will depend on the topic selected.

## Advanced Plasma Physics (7403-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

Equilibrium and stability, Kinetic theory, Nonlinear effects, Classification of Plasmas, Approximation methods,

**List of Required Textbooks**

1. Goldston, R. J. (2020). Introduction to plasma physics. CRC Press.

2. Chen, F. (2015). Introduction to plasma physics and controlled fusion. Springer.

## Advanced Fluid Mechanics (7404-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

The course covers a range of essential topics, including turbulent flows, non-Newtonian fluid flows, fluid flows in porous media, and fluid flows involving phase change. It also explores convective-diffusive heat and mass transfers, fluid flows with free surfaces, and the numerical simulation of transport phenomena. Together, these areas provide a strong foundation for analyzing and simulating

complex fluid dynamics and heat transfer processes across diverse scientific and engineering applications.

**List of Required Textbooks**

1. Fundamentals of Fluid Mechanics, Bruce R. Munson, Alric P. Rothmayer, Theodore H. Okiishi, Wade W. Huebsch, Wiley, 7th edition (2012).

2. Fluid Mechanics, Fifth edition, John F. Douglas, Janusz M. Gasiorek, 2006.

## Magneto-Hydrodynamics (7405-Phys)

Credit hours: 3 (3+0+0) Level: 3 /Year: 2

**Course Description:**

This course provides a comprehensive introduction to Magnetohydrodynamics (MHD), exploring the interplay between magnetic fields and fluid dynamics in conducting fluids. Key topics include the Navier-Stokes and Maxwell equations, along with the associated dimensionless parameters that govern MHD behaviour. Students will delve into the propagation of electromagnetic waves at dielectric boundaries and examine both Lagrangian and Hamiltonian energy equations of motion. The course will also cover the solutions of MHD flows in various channel configurations, as well as MHD convection phenomena in enclosures filled with nanofluids. Through theoretical exploration and practical applications, participants will gain a solid foundation in the principles and applications of MHD.

**List of Required Textbooks**

1. Fluid Mechanics, F. White, McGraw-Hill Education, 8$^{th}$ edition (2015).

2. Magnetohydrodynamics: With an Appendix on Extended MHD.Springer, (2009).

## Selected Topics in Plasma and Fluid Physics (7406-Phys)

Credit hours: 3 (2+1+0) Level: 3 /Year: 2

**Course Description:**

This course tackles a variety of selected topics in the field of plasma and fluid physics related to faculty expertise and student needs. Topics in this course should provide the students with extended knowledge of the subject adding to that covered by earlier course. Topics will be selected based on the instructor and the student research direction.

**List of Required Textbooks**

Textbooks will depend on the topic selected.

## Advanced Research Topics (7501-Phys)

Credit hours: 3 (0+1+2) Level: 4 /Year: 2

**Course Description:**

This course aims to assist PhD students in formulating their research proposals and clarifying their methodological approach. This will give students a comprehensive overview in their area of research, including its methodology, problems and structure. Students will be acquainted with many research tools and prepared to strategize and structure their study while articulating their findings. This course is designed to provide research training, equipping students with specialized information and abilities pertinent to their research topic. This includes the compilation of a literature review, the composition of scientific papers, and the delivery of oral presentations and other formal communications.

**List of Required Textbooks**

Textbooks will depend on the topic selected.

**Dissertation (7600-Phys)**

Credit hours: 9 (0+3+6) Level: 5 /Year: 3

**Course Description:**

This course requires each Ph.D. candidate to submit a written dissertation based on independent research conducted under the supervision of an academic advisor. The dissertation must include original contributions and offer new insights related to the research focus. Additionally, candidates are required to defend their dissertation before a panel of experts appointed by the department.

**List of Required Textbooks**

Lab manuals, research articles.