LUMS
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Learning Without Borders

EXPLORING GRADUATE STUDIES: PHYSICS

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Office of Academic Advising and Student Success

After students finish their undergraduate degree, they can pursue professional development or further studies (or both). In either case, it is important to make an informed decision as soon as possible. With regards to the latter, ***the earlier students can decide that they might want to go for graduate studies, the more they can do to improve their chances of admission,*** *therefore this handout has been designed to facilitate the process for candidates wishing to pursue graduate studies.*

This is a summary document outlining ***what students need to do during their undergraduate degree and what fresh graduates may need to do*** *to be better prepared for applying to graduate school. Please note this resource was last updated on* ***08/16/2022****, and some information may be outdated, therefore after closely reviewing the information below we encourage readers to consult with faculty, alumni from your field of interest, and other people who have pursued this graduate degree to learn more.* ***For in-depth information on graduate programme exploration, career prospects, graduate school application process, funding, and more, please check out the detailed doc here (under development).***

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SECTION 1: ACADEMIC BACKGROUND

A. Are there any Degree requirements?
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Are there any Degree requirements?

Note: Since the information is regarding general requirements, students should contact their prospective programmes in advance and find out the exact degree requirements.

General Information

- **For Master's degrees (MA, MSc, etc.),** having a bachelor's degree in Physics is highly recommended since a degree in Physics allows students to take the required coursework and take part in relevant research experiences. Students may also find an Engineering or a Maths degree good to have as they too help in developing quantitative and analytical skills required to succeed as a Physics graduate student.
    - *Note: Non-Physics students are likely to not have taken the required/highly recommended Physics coursework so to compensate for this weakness they are highly encouraged to take GRE in Physics and do well in it to demonstrate they have sufficient theoretical knowledge and skills required for a Master's in Physics.*

- **For Doctorate level degrees,** a Master's degree in Physics is generally a requirement. If students don't have this, then a Physics-related degree and/or extensive research experience in the field of Physics/Engineering may allow them to compensate for the lack of academic background (students should make sure to contact the programme to find out if they will accept their credentials because some programmes are very strict in their requirement for a Physics graduate degree).

Country-Specific considerations

Note: These are not all country-specific considerations and if students are interested in a particular country not mentioned in the list below, they should make sure to contact their prospective programmes in advance and find out the exact degree options and their requirements.

- **The US/Canada:**
    - **A bachelor's in Physics or a closely related field (Math/Engineering, etc.) is often required for admission into a Master's programme.** Candidates coming from a non-Physics background are strongly recommended to take the required coursework in Physics and take part in extensive research experiences in their specialisation of interest.
    - **North American Physics PhD programmes generally do not require applicants to have a Master's degree**, therefore undergraduate applicants may be directly admitted into the PhD programme.

- **The UK:**
    - **For admission into a Master's programme, applicants are generally required to have an undergraduate degree in Physics** (or any other equivalent Engineering-based degree).
    - **If applicants have none of these qualifications,** they will have to prove to the university that they have a significant amount of knowledge in the field of Physics, through work/research experience for example, or by working as a research assistant. In this scenario, chances of admission are lower but possible (some universities accept research/work experience as compensation for a lack of academic background in Physics, but not all do so it is important to check programme requirements).

If you have not completed your undergraduate degree in Physics:

- **In some cases, Master's programmes may accept students who come from a closely related undergraduate background such as Engineering or Math and have also satisfied the undergraduate coursework requirements.**
- **In this case, you should try to take many courses/electives in Physics.** Then in your application, make sure to emphasise your Physics background, despite lacking the degree. You can also consider auditing Physics courses or taking online courses relevant to your prospective specialisation to help strengthen your chances of admission, as mentioned above. However, it is entirely up to the discretion of the university admissions committee on whether they will offer you admission.
- **For PhD admissions, students are highly encouraged to pursue a Master's in Physics first** as that will allow them to make up for academic/research gaps needed for PhD admissions.
- **You are highly encouraged to pursue relevant research experience.** Relevant research experiences such as pursuing research assistantships in your subfield of interest (e.g. BioPhysics) can demonstrate to admissions committees that you have a good understanding of physical laws and principles.

Are there any Coursework requirements?

Note: Students should make sure to contact their prospective programmes in advance and find out what the exact course requirements are.

General Information

- **For Master's degree:**
  - If you are a Physics Major: There may be no additional coursework requirements as the core courses are already covered by the Physics degree but students should also check out 'Subfield-Specific Courses' if they have a specialisation interest and 'Other Useful Courses' for further skill development.
  - If you have a non-Physics background: Students are recommended to take as many of the 'Key Courses' listed below as possible, and also take some of these 'Other Useful Courses' for skill development. Furthermore, taking sub-field-specific Physics courses relevant to what they want to specialise in may be a good way to demonstrate their passion and interest in studying Physics to the admissions committees.

- **For Doctorate level degree:**
  Note: Undergraduate students that are aiming for direct admission into a PhD programme are highly recommended to pursue graduate-level Physics courses along with substantial research experiences to be better prepared for doctoral studies in Physics.
  - If you are a Physics Major: There are no additional coursework requirements but since the degree is research-intensive, students should plan on taking 'Subfield-Specific Courses' as per their research interest and are also highly encouraged to check out 'Other Useful Courses' for skill development needed to succeed as a PhD student.
  - If you have a non-Physics background: Since non-Physics students may be required to pursue a Masters in Physics to be better prepared for a PhD in Physics, they are highly recommended to take the 'Key Courses' listed below to fulfil admission requirements for a Master's programme. Furthermore, students should also plan on taking 'Subfield-Specific Courses' as per their research interest and 'Other Useful Courses' that are required for skill development needed to succeed in a PhD programme.

Key Courses

Note: This is not an exhaustive list but the following core courses are generally covered in a typical Physics undergraduate programme. If students are struggling in taking some of the key courses, here are some tips to compensate for that. Some requirements vary according to country, so for these details please click here.

Physics Courses:

- Mechanics
- Modern Physics

- Electricity and Magnetism
- Quantum Mechanics
- Experimental Physics
- Electromagnetic Fields and Waves
- Classical Mechanics
- Statistical Mechanics
- Condensed Matter Physics
- Relativistic Electrodynamics

Maths Courses:

- Calculus
- Multivariable Calculus
- Linear Algebra
- Differential Equations

Sub-field Specific Courses

Note: If your university does not cover any of the following concepts, online courses that cover the topics can be taken as well. If you are interested in concentrating on a subfield not mentioned in the list below, then you should plan to take courses in that subfield.

- **For students wishing to specialise in Astrophysics,** courses that cover planetary physics, cosmology, the workings and evolution of the universe and structures located within including stars, black holes, and galaxies would be useful.
- **For students wishing to study Condensed Matter and Surface Science Physics,** physics and chemistry courses that cover condensed matter physics, including phenomena at atomic, nano-, meso- and macroscopic scales for crystalline solids and amorphous materials can be useful.
- **If students are interested in Nuclear and Particle Physics** then they should consider taking courses that cover subatomic particles (e.g. quark-and-gluon substructures of nucleons, complex nucleic composition, etc.), application of nuclear physics, astrophysics, quantum field theory, etc.
- **For students interested in pursuing further studies in BioPhysics,** they should plan on taking courses that cover Biology, Biostatistics, and Chemistry to develop the required life sciences background.
- **Students that are interested in doing their graduate studies in Quantum Computing** can find courses that cover Quantum Computing, Quantum Information Systems, and Computational Physics useful.

Other Useful Courses

Note: Students should focus on taking courses that will help them develop the relevant skills mentioned below to be successful as physics graduate students and physicists.

- **Advanced Math Courses:** Advanced Math courses such as advanced calculus, probability, mathematical statistics, real analysis, complex numbers, etc. can be helpful, especially for students planning on pursuing a PhD in Mathematical Physics.

- **Computer Science courses:** Physics graduate students can benefit from building on their programming and data analytic skills. Though Physics graduate students do not have to be expert programmers, many are, and all physicists tend to be competent programmers. Furthermore, the data analysis process in most experiments is complex enough to require some programming background for which undergraduate courses that cover programming, Data structures, Database management, Machine Learning, and Artificial Intelligence (AI) can be good to have.

- **Writing and Communication Courses:** These courses are generally useful for developing writing and research skills needed to succeed as Physics graduate students. Graduate courses in Physics can be reading, writing and research-intensive therefore students can benefit from taking these courses. Furthermore, graduate students may

be required to present their research findings to other researchers and graduate students and this may require public speaking skills.

- **Philosophy Courses:** Contrary to popular opinion, Physics and Philosophy have a lot more in common than one might think. A background in Philosophy allows students to understand concepts in Physics from a philosophical perspective and to gain a deeper understanding of how each concept impacts humans and society.

If you were unable to take the required/recommended courses:

- **Applicants are generally required to demonstrate sufficient theoretical knowledge in Physics.** Therefore, you can consider auditing Physics courses or taking online courses relevant to their prospective specialisation to help strengthen your chances of admission, as mentioned above. Online platforms such as **LinkedIn Learning, Coursera, Skillshare, and Udemy** offer courses on various topics and subfields of Physics at varying skill set levels.
- **You should focus on taking the Physics GRE.** The aim of this test is to determine the extent of the examinees' grasp of fundamental Physics principles and their ability to apply these principles in the solution of problems.

Are there any GPA requirements?

Note: The following requirements are averages -- it is possible that universities have higher or lower standards for entry.
Also note: Requirements vary according to country and programme -- it is recommended that students contact their prospective programmes and find out the exact GPA requirements.

General Information

For more tips on coursework and GPA, check out these general tips (under the tab 'Transcripts').

- **GPA is considered an important factor for admission,** and so if possible, students should work to get the best grades they can (especially in Physics, Maths, or Science-related courses where applicable).
- **Admission committees generally give more weightage to applicants' grades in advanced elective courses than in basic and initial courses.** Therefore, even if applicants may have lower grades in their first or second years, they can still greatly increase their chances of admission by performing better in the third and fourth years.

- **For Master's degrees:**
  - **For the US/Canada:** The minimum acceptable undergraduate GPA is around 3.0 (on a 4.0 scale)
  - **For the UK:** Academic requirements vary across universities but all require at least a 2:2 degree (usually equivalent to a 3.0 GPA/B grade) at the undergraduate level.

- **For Doctorate programmes:**
  - **For the US/Canada:** The minimum acceptable undergraduate GPA is usually 3.3 (on a 4.0 scale)
  - **For the UK:** An undergraduate GPA of 3.2+ (on a 4.0 scale) along with an equivalent Master's degree at merit level.

For Top-Tier programmes

- **For Master's degrees (MA, MSc, etc.):**
  - **For the US/UK/Canada:** There are often no explicit GPA requirements but a minimum GPA of 3.6+ (on a 4.0 scale) is highly recommended.
- **For Doctorate programmes:**
  - **The UK:** Some universities may require a high 2:1 (equivalent to 3.3-3.7 GPA) or a First (equivalent to 4.0 GPA). Furthermore, top-tier PhD programmes may also require an Honors degree in Physics.
  - **The US/Canada:** A GPA of 3.7+ (on a 4.0 scale) undergraduate GPA is generally required but the admissions committees generally take a holistic approach to applications. For example, if an applicant has relevant

undergraduate research experience or has stellar letters of recommendation, then that may compensate for a lower GPA.

If you do not meet the minimum GPA requirements:

- **Then you should contact the graduate programme and ask them if there are any actions you can take to still be considered.** If you have a good amount of relevant research experience in the field, then that can sometimes compensate for a low GPA but it is up to the programme.
- **You are highly encouraged to talk to your university academic advisors** who can support you in improving your GPA.

SECTION 2: NON-ACADEMIC BACKGROUND

A. Are there any Work Experience requirements?
B. Are there any Research Experience requirements?
C. Are there any Extracurricular Experience requirements?

Are there any Work Experience requirements?

Note: Students should make sure to contact their prospective programmes in advance and find out the exact work experience requirements.

- **Work experience is not required for admission into a Physics graduate programme,** and does not ensure acceptance as Master's admission committees focus more on the applicant's academic background while doctoral programmes focus on academic and research experiences exclusively.
- **Relevant work experiences can be good to have to support academic/research background.** Work experience in the research industry (For e.g. Physicists working in the aeronautical industry) working their way up as Teaching assistants/Engineers can demonstrate a passion for the field of Physics along with the required theoretical knowledge and research skills.
- **Useful skills to show through work experience:**
  - Subject Knowledge
  - Organisation skills
  - Linear thinking
  - Strong research skills
  - Good writing skills

If you do not have sufficient work experience:

- **Applicants should understand that work experience is not required nor recommended for graduate school admission.** Nonetheless, if you are confused about whether your work experience is enough to get you through, it is a good idea to reach out to the universities you are applying to and ask them whether your work experience is enough to make you a strong candidate for admission.

Are there any Research Experience requirements?

Note: Students should contact their prospective programmes in advance and find out the exact research experience requirements.

- **For Master's degrees, research experience is not a requirement** as undergraduate research experience can be difficult to get in this field**.** It can be good to have, especially if applicants have weak academic requirements.
- **For doctoral degrees, undergraduate-level research experience is not a requirement but highly recommended if undergrad students are planning on directly entering a PhD programme.** Students can choose to take a gap year and further their senior year research Physics project (SProj) in one specialised research area under the direct supervision of a faculty member. Students can explore different research routes/directions along with consultation from a faculty.
- **For students planning on going for a PhD after a Master's degree, graduate-level research experience may be required** as the degree itself is research-intensive. Applicants should mention their research proposal components in their application as that could be very important.
- **Other relevant research experiences include:** Publishing a research paper or presenting at a research conference.

If you do not have sufficient undergraduate research experience:

- **Students should understand that research experience is not a requirement for entry into a Master's programme;** however, they should contact their programmes of interest to find the exact research requirements.
- **Admission committees of doctoral programmes usually only look at the applicant's graduate-level research experience** while research experience at the undergraduate level can be considered good to have.
- **Undergraduate students that are originally planning on applying to direct PhD admissions but lack sufficient research experience are highly recommended to go for a research-intensive Master's programme instead first** to get sufficient research experience to make them eligible for PhD admissions.

Are there any Extracurricular Experience requirements?

- **Any experience (clubs, societies, competitions, etc.) that helps in developing leadership skills (and other relevant skills) is helpful.**
- **Most applicants have some sort of prior volunteer experience at Physics related seminars and events** to develop knowledge about contemporary research topics in Physics but it is not a requirement. To get an idea about relevant voluntary work in Science related events, please check here.

SECTION 3: WHAT DOES IT MEAN FOR LUMS STUDENTS?

A. General Information
B. Students that are planning on pursuing the Physics programme
C. For Physics Students
D. For non-Physics students
E. Non-Academic Experiences

General Information

- **LUMS students should reach out to their respective Academic Advising Unit (AU) staff and faculty early** for careful course planning given the recurring issues in enrollment at LUMS.
- **LUMS students should refer to the course memos** (courses being offered in a specific semester and their requirements) for a more updated list of courses **and the course outlines** (resources to help students understand the course) to know the topics being taught within those courses.
- **For understanding the course auditing process,** students should check the Undergraduate Student Handbook (please download the handbook relevant for your academic year) and contact advising units or department coordinators for further information.
- **Students should connect with SBASSE faculty via advising units.** Faculty are the best source of information on what academic and non-academic experiences students should pursue to become strong candidates for graduate studies.
- **Keep a lookout for workshops, sessions, and events organised by SBASSE on the Advising Portal Calendar** as attending such events can give students more exposure to the field of Physics.
- **For information regarding the various academic/non-academic related support services at LUMS,** please check here.
- **LUMS students should contact the Career Services Office to get assistance in areas of career planning and work experience opportunities.** Students should also reach out to alumni using online platforms such as the LUMS discussion forum and LinkedIn.
- **For an updated list of clubs and societies** operating under the LUMS Office of Student Affairs (OSA), please check here.

Students that are planning on pursuing the Physics programme

- **Students should learn more about the Physics programme offered at LUMS, by exploring the SBASSE website and the Physics Major Exploration Document.** The Major Exploration Handout will guide undergraduate students on how they can make the most of their Physics degree, and help them decide whether to transfer or not into the Physics programme or how students can get exposure to the Physics field without majoring in it.
- **Students that are interested in choosing a Physics major should take introductory Physics courses** such as Modern Physics, Electricity and Magnetism, Mechanics, Mathematical Methods in Physics and Engineering, etc. For help with choosing a major, please check out here.
- **For students interested in transferring into the Physics programme,** they should check out the Inter-School Transfer Handout and contact the advising units of both their school and SBASSE.

For Physics students

- **Students should check out the Physics Major Exploration Handout section on how to make the most of their major** This section covers resources that are available to Physics students, managing course selection, academic strategies to succeed as Physics students, and information on complementary experiences to make the most of their BSc. degree.

- **Students are required to take Core Courses as part of their Physics programme** including but not limited to Calculus II, Electricity and Magnetism, Mechanics, Quantum Mechanics, Modern Physics, Mathematical Methods in Physics and Engineering, Experimental Physics, Electromagnetic Fields and Waves, etc. These courses are also helpful when students are trying to gauge what speciality they will pursue for graduate studies in the future.
- **Students that have decided on their area of specialisation in further studies should take relevant Physics/Science electives.** E.g., students that are planning on studying Quantum Computing can find courses that cover Quantum Computing, Quantum Information Systems, and Computational Physics useful.
- **Students should consider doing a minor in a STEM/social science subject** as they promote the development of soft skills needed for Physics graduate students such as writing skills, quantitative skills, communication skills, etc. For help with choosing a minor, please check out here.
- **Students are highly encouraged to take non-Physics courses/electives that will contribute to building skills needed to be successful as a Physicist and science student.** E.g., English and Philosophy courses can assist students with developing relevant skills (communication skills, writing skills, understanding of logic, socio-cultural awareness, etc.)
- **Students should talk to the Physics faculty.** Establishing a strong relationship with faculty members may be useful for research/teaching-assistantship opportunities and getting strong letters of recommendation needed for graduate studies.

For non-Physics students

- **Students should consider taking a closely related major such as Maths, Electrical Engineering, Chemical Engineering, etc.** as the coursework can help students develop relevant quantitative skills needed to succeed as Physics graduate students.
- **Students should plan on taking as many Physics core courses as they can to develop the required knowledge of the field.** Students may benefit from minoring in Physics to not only take Physics courses but to also demonstrate an interest in the field to admissions committees.

Non-Academic Experiences

- **Students are highly encouraged to pursue Teaching Assistantships with the Physics Faculty** as they provide an opportunity to reinforce concepts learned in Physics classes and identify knowledge gaps that can be addressed through academic/non-academic opportunities. Furthermore, TA-ships are a good opportunity to get guidance for graduate school admissions directly from faculty, and forming long-term connections with professors by assisting them with their classwork may help in getting letters of recommendation required for graduate school admissions.
- **Students are encouraged to look for research-oriented internships.** The Physics department opens a lot of research opportunities at LUMS for students during the summer break. If students want to work in industry after graduation then managerial internships will be valuable for them.
- **Students should consider various on-campus research opportunities such as Sproj, Independent Study, RA-ships, etc.**
    - Sproj (Senior Year Research Project) allows students to pick a topic in the field of Physics, conduct quantitative/qualitative research, and write a research paper on it. This not only helps in developing research skills, writing skills, and presentation skills but also mirrors the research work that students will be undertaking in their PhD programme or research-intensive courses in their Master's degree.
    - For information regarding undergraduate research opportunities, please check here.
- **There are specific societies geared toward the field of Physics such as** the Society for Promotion and Development of Engineering and Sciences (SPADES), IEEE, LUMS Women in Computing (LWiC), LUMS Students Mathematics Society (LSMS), LUMS Entrepreneurial Society (LES), LUMS Data Science Society (LDSS) where students can do skill-building and networking for relevant Physics or Engineering-related work/research opportunities.

SECTION 4: APPENDIX

A. Sources you should consult for more information
B. Online Resources Consulted
C. Contributors

Sources you should consult for more information

- Graduate Studies Guidebook - Physics (under development)

Online Resources Consulted

- MSc Physics Admissions in Pakistan
- MS Physics Admission Requirements by LUMS
- Which Physics Concentration is Right for you?
- Planning for Graduate Studies in Physics
- Best US Physics Schools by Sub-Speciality
- How to become a good Theoretical Physicist
- Physics Doctorates Initial Employment
- Common Careers of Physicists in the Private Sector
- Tips on Grad School Applications by Columbia University - Physics Department
- Guide to Applying to US Science PhD programmes and Fellowships by DJ STROUSE
- How to get into graduate school by Sean Carroll
- Grad School Applications by Alex Lang
- Advice for Physics Students Considering Graduate programmes by David Wittman
- Choosing a Graduate School in Physics and Related Disciplines by American Physics Society
- Applying To Grad School by American Astronomical Society
- Various University Acceptance Rate - Physics Department by GradSchoolShopper
- Advice for PhD students seeking industry jobs by Bhaskar Krishnamachari's blog on Academic Freedom
- Pursuing a PhD in Physics by C.Marcelle Buford - AAAS (Advance Science, Serving Society)
- Why Study Physics? By UCL
- Admission Requirements of a Physics Graduate School programme in Canada
- Example of Admission Requirements of a Physics Graduate School programme in the UK
- Top Physics Graduate School programmes in the US
- Top Physics Masters programmes in the UK
- Top Physics PhD programmes in the UK
- Physics Masters programmes in Canada
- Physics PhD programmes in Canada
- Physics Graduate School Personal Statement Samples

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