Boston University Physics Department
PY401 – PY402
SENIOR INDEPENDENT WORK

The Departmental Senior Independent Work, also referred to as Honors Thesis or Work for Distinction, is an opportunity for students to conduct in-depth research as a capstone project in their undergraduate education. An undergraduate thesis provides an opportunity to explore a specific topic or question in depth, beyond what is possible in a regular course. Independent study encourages a deeper understanding of the subject matter and helps develop critical thinking and research skills. Writing and defending a thesis develops skills in background research, technical writing, and oral presentation. Students in the Physics major as well as any of our joint majors are eligible to complete an Honors Thesis. The Senior Honors Thesis is a two-semester endeavor, requiring 8 credit hours of directed study. Concurrent support by UROP or other research funds is allowed.

There is no formal GPA requirement, but it is expected that only students with a strong performance in coursework should elect to pursue an Honors thesis. Academic performance will be a criterion under consideration for approval.

Students will register for CAS PY401 and CAS PY402 in their senior year. Before registration for PY401, the student will identify a faculty research supervisor and produce a research proposal to be approved by the research supervisor and Physics Department Director of Undergraduate Studies. The format of the proposal is a written narrative describing the topic, the goals of the research, and a plan and timeline for accomplishing the work. The proposal should identify two additional committee members who will review the work upon completion. Proposals should be submitted as a PDF document to the Physics Department Undergraduate Program Coordinator and will be reviewed by the Physics Department Director of Undergraduate Studies. The Physics Department Undergraduate Program Coordinator will complete the registration for the PY401 and PY402 courses on your behalf.

SYLLABUS

The Senior Independent Work begins with the research proposal submitted before registration. The first semester will include the first foray into experimental measurement, simulation, model building, or theoretical calculation that is the topic of the thesis. As the research develops, changes in direction are frequently encountered and should be taken in stride and documented.

BU Hub Learning Outcomes for PY401

Intellectual Toolkit: Research and Information Literacy
Learning Outcome 1: Students will be able to search for, select, and use a range of publicly available and discipline-specific information sources ethically and strategically to address research questions.

During the first semester, the student is expected to undertake an extensive and systematic effort to study specialized background material relevant to the research, covering topics that are likely absent from the traditional physics curriculum in classical and quantum physics. Students will fill

gaps in their general understanding by reading books and review articles which address the theoretical and technical background for the issues that the student encounters. Students will also read papers which are focused more narrowly, and more closely related to their project. Many students will also need to hone technical skills related to detectors, data acquisition, analysis, and simulation, requiring narrow and detailed reading. The student should curate the collection of relevant publications and establish a detailed bibliography. The advisor will guide the student on how to search, select, and use information based on the databases and best practices in their experience.

Intellectual Toolkit: Research and Information Literacy
Learning Outcome 2: Students will demonstrate understanding of the overall research process and its component parts and be able to formulate good research questions or hypotheses, gather and analyze information, and critique, interpret, and communicate findings.

The formation of a solid research question or hypothesis is a required element of an Honors Thesis. Developing a clear statement will be a central activity over the course of the first semester. Through careful planning and consultation with their advisor and research groups, Honors Thesis students will learn to break a project into key components and to identify and carry out the necessary research to complete each of them. The deliverable result will be a formal Abstract and detailed Outline upon which the Honors Thesis writing is based. General research progress will be supported by regular meetings and presentations throughout the first semester, ideally to the broader audience of a research group.

Communication: Oral and/or Signed Communication
Learning Outcome 1: Students will be able to craft and deliver responsible, considered, and well structured oral and/or signed arguments using media and modes of expression appropriate to the situation.

Senior Independent Work culminates in a formal presentation, however, that presentation should be only one of many given by the student over the course of the two-semester sequence. During the first semester students will give frequent and relatively informal presentations to a research group, who are probably already conversant in the details of a student's project. Research groups generally meet weekly. Students may deliver presentations to other students, such as the Student Physics Society, UROP poster sessions, or specially arranged symposia of the cadre of Honors Thesis students. The faculty mentor will work with the student on crafting the level of detail appropriate to the audience: both the media (usually slides) and the oral presentation.

Communication: Oral and/or Signed Communication
Learning outcome 2: Students will demonstrate an understanding that oral/signed communication is generally interactive, and they should be able to attend and respond thoughtfully to others.

Presentations made by the students will be naturally interactive in the context of research group meetings. A key element of the learning will occur when the student is part of the audience to presentations by peers and more experienced collaborators. Appreciating the practices that work well (or not so well) as found in research meetings will be valuable in helping the student craft their own communication style. The student will be expected to engage in thoughtful questioning to other presentations.

Communication: Oral and/or Signed Communication
Learning Outcome 3: Students will be able to speak/sign effectively in situations ranging from the formal to the extemporaneous and interact comfortably with diverse audiences.

Novice students in the audience will probably know the least but ask the most demanding questions. Experienced collaborators will want clear answers to bottom-line questions. Students will learn how to answer questions in a manner that shows their understanding of the subject without boring or confusing audience. The most formal communication will occur in the defense of the research to a panel of faculty at the conclusion of the Honors Thesis project.

BU Hub Learning Outcomes for PY402

The Honors Thesis is an extended written argument that is written in a style and structure that is comparable to a Ph.D. dissertation, but of a shorter length (50-100 pages) and expectations, commensurate with undergraduate research of approximately one year duration.

Prerequisite: First-Year Writing (e.g. WR100 or WR120).

Communication: Writing-Intensive
Learning outcome 1: Students will be able to craft responsible, considered, and well-structured written arguments, using media and modes of expression appropriate to the situation.

At the beginning of PY 402, the student and research advisor will develop a writing schedule, along with a plan for any remaining literature review or scientific research. This schedule is a deliverable and should be shared and reviewed by the PY402 cadre (students plus advisors) by the second week of the semester. Over the course of PY402, students will submit multiple drafts chapter-by-chapter, following the outline and schedule, but being mindful that in-depth research and documentation may reveal directions of inquiry that derail expectations. Chapters will be improved through revision with weekly meetings between student and research advisor. The written Honors Thesis will be delivered in draft form before the Thesis Defense and undergo final revision based on the comments from the Thesis Committee. The final written thesis is due by the last day of instruction of the Spring semester.

Communication: Writing-Intensive
Learning outcome 2: Students will be able to read with understanding, engagement, appreciation, and critical judgment.

With the guidance of their advisor, the student will learn to read and extract critical and relevant information from physics journal articles. The student and advisor will select at least one such article and the student will present their understanding of it in a "Journal Club" format to an assembly of interested students and faculty. Ideally, this article will be central to the student's research topic in some way, perhaps as prior work, or foundational theory or measurement, or a review of the area of the Honors Thesis topic. The "Journal Club" presentation could take place during either PY401 or PY402.

Communication: Writing-Intensive
Learning outcome 3: Students will be able to write clearly and coherently in a range of modes and styles, integrating graphic, multimedia, and other elements as appropriate to the genre.

The Honors Thesis mode and style is most similar to a Ph.D. dissertation, and will include suitable graphics, tables, and properly typeset equations. The Thesis must include a clear introduction, accessible to the broadest audience, as well as appropriately technical chapters that are aimed at expert readers. The student will read the introduction to one or more Ph.D. theses connected with their research topic and comment critically on the success or struggles of the author in writing an accessible introduction. The main body of the thesis will be technical and best appreciated by experts. The writing (but not layout) should follow conventions applied to refereed journal articles. The research advisor will provide references on technical writing[1] and give significant feedback through proofreading.

Grading for PY401 and PY402

Specific grade weights will be decided by the advisor in consultation with the student. The basic principle is that roughly half the work of the Honors Thesis project should be completed by the end of the first semester (i.e. PY401), but the blend of written work and research will vary by student and project. The work during the second semester (i.e. PY402) should be predominantly writing and revision of the thesis and preparation of a final oral defense.

[1] The Review of Modern Physics editor provides this style guide with examples taken from the language of physics research: https://cdn.journals.aps.org/files/rmpguapa.pdf. There are also a variety of texts on technical writing for scientists and physicists that would be instructive.