

**Important Note:** Every effort will be made to avoid changing the course schedule, but the possibility exists that unforeseen events will make syllabus changes necessary. It is your responsibility to check Blackboard for corrections or updates to the syllabus. Any changes will be clearly noted in course announcements or through Stony Brook email.

### Part 1: Course Information

**Course title:** Advanced Theoretical Particle Physics

**Course catalog # and section:** PHY613

**Semester:** Spring 2022

**Prerequisites:** The course prerequisites include a working knowledge of quantum field theory and the Standard Model (SM), as covered in the PHY 610, 611, 612 sequence at Stony Brook. If a student has equivalent preparation as part of an M.A. or M.S. degree, this should be acceptable; the student should check with the instructors.

**Instructors' names:** Professors Rouven Essig, Patrick Meade, Robert Shrock, George Sterman

**Instructors' email addresses:** [rouven.essig@stonybrook.edu](mailto:rouven.essig@stonybrook.edu), [patrick.meade@stonybrook.edu](mailto:patrick.meade@stonybrook.edu), [robert.shrock@stonybrook.edu](mailto:robert.shrock@stonybrook.edu), [george.sterman@stonybrook.edu](mailto:george.sterman@stonybrook.edu)

**Office hours:** By appointment (contact via email).

**TA Information:** N/A

#### **Course Description:**

Each instructor will teach about one fourth of the course. The course will cover selected topics from the list below:

- Effective field theory; application to the Standard Model and physics beyond the Standard Model
- Electroweak interactions, quark mixing, neutrino masses and mixing
- Lattice gauge theory and applications to QCD including confinement, spontaneous chiral symmetry breaking, and hadron masses
- Grand unification and predictions for baryon-number violation



- Dark matter, primordial nucleosynthesis, early universe cosmology.
- Quantum chromodynamics (QCD): deep inelastic scattering, asymptotic freedom, infrared safety, jets, parton distributions, factorizations and resummations; instantons: Peccei-Quinn symmetry and axions.

**Course Textbook and Materials:**

- The course does not have a formal textbook but books such as P. Langacker, *“The Standard Model and Beyond”*, M. Schwartz, *“Quantum Field Theory and the Standard Model”*, C. Quigg *“Gauge Theories of Strong, Weak, and Electromagnetic Interactions”*, and D. Gorbunov and V. Rubakov, *“Introduction to the Theory of the Early Universe: Hot Big Bang Theory”* are useful for background. Course materials will also be drawn from various websites.

**Course Delivery Mode and Structure:**

The mode of delivery for this course will be determined by the COVID situation in Spring, 2022. Some of the information below is included in case the delivery mode is online or hybrid rather than in-person. In the online or hybrid cases lectures will be delivered synchronously via Zoom. Students must be mindful of all course expectations, deliverables and due dates, especially because the online portion of the course requires significant time management. All assignments and course interactions will utilize internet technology.

You may access online lessons, course materials, and resources.

**How We Will Communicate:**

Course-related questions should be posted in the General Questions Forum in the course Discussion board. For personal/private issues, email the relevant instructor(s) directly. If you use Blackboard’s **email tool** from the course site, it will automatically include your full name, course name and section when you send an email. **Please allow between 24-48 hours for an email reply.** Your Stony Brook University email must be used for all University-related communications. You must have an active Stony Brook University email account and access to the Internet. All instructor correspondence will be sent to your SBU email account. **Plan on checking your SBU email account regularly for course-related messages.** To log in to Stony Brook Google Mail, go to <http://www.stonybrook.edu/mycloud> and sign in with your NetID and password.

Regular announcements will be sent from Blackboard. These will be posted in the course site and may or may not be sent by email.

Regular communication is essential in online classes. Logging in once a day, checking the discussion board and participating with your peers ensures that you are able to remain an active member of the class and earn full points for participation.

**Technical Requirements:**

This course uses Blackboard for the facilitation of communications between faculty and students, submission of assignments, and posting of grades and feedback. The Blackboard course site can be accessed at <https://blackboard.stonybrook.edu>

If you are unsure of your NetID, visit <https://it.stonybrook.edu/help/kb/finding-your-netid-and-password> for more information. You are responsible for having a reliable computer and Internet connection throughout the term. **Caution!** You will be at a disadvantage if you attempt to complete all coursework on a smart phone or tablet. It may not be possible to submit the files required for your homework assignments.

Students should be able to use email, a word processor, spreadsheet program, and presentation software to complete this course successfully.

The following list details a minimum recommended computer set-up and the software packages you will need to have access to, and be able to use:

- PC with Windows 10 or higher (we recommend a 3-year Warranty)
- Macintosh with OS 10.11 or higher (we recommend a 3-year Warranty)
- Intel Core i5 or higher
- 250 GB Hard Drive
- 8 GB RAM
- Latest version of Chrome or Firefox; Mac users may use Chrome or Firefox. (A complete list of supported browsers and operating systems can be found on the My Institution page when you log in to Blackboard.)
- High speed internet connection
- Word processing software (Microsoft Word, Google Docs, etc.)
- Headphones or earbuds, and a microphone
- Webcam (recommended)
- Printer (optional)
- Ability to download and install free software applications and plug-ins (note: you must have administrator access to install applications and plug-ins).

**Technical Assistance:**

If you need technical assistance at any time during the course or to report a problem with Blackboard you can:

- Phone: 631-632-9800 (client support, Wi-Fi, software and hardware)
- Submit a help request ticket: <https://it.stonybrook.edu/services/itsm>
- If you are on campus, visit the Walk-Up Tech Support Station in the Educational Communications Center (ECC) building.

**Part 2: Course Learning Objectives and Assessments**

Upon completion of the course, students will know several topics in modern advanced particle theory at a level that will help them begin Ph.D. thesis research, including a selection of topics from quark masses and mixing, neutrino masses and lepton mixing, quantum chromodynamics, Higgs physics, grand unified theories, dark matter, and other materials from cosmology.

**How to Succeed in this Course:**

- Attend all lectures.
- Complete all assigned readings in the course.
- Correctly complete all assigned homework on time.

**Part 3: Course Schedule**

The class will meet online on Tuesdays and Thursdays at 1:15pm to 2:35pm.

**Part 4: Grading, Attendance, and Late Work Policies**

**Assessment and Grading:** There will be homework assignments that need to be completed over the semester. There is no midterm or final exam.

**Viewing Grades on Blackboard:** The homework assignments will typically be graded within two weeks of submission. Some evaluations may also be posted on Blackboard in accordance with considerations of student privacy.

**Letter Grades:** Final grades assigned for this course will be based on the percentage of total points earned and are determined after evaluating the performance of the class overall.

**Attendance Policy:** You are strongly encouraged to attend all lectures.

**Late Work Policy:** Assignments should be handed in when they are due, since it is important to keep up with the course. Late homework submissions will receive reduced credit. Exemptions will be made for students who are infected with COVID-19 or have other significant medical problems.

**Part 5: University and Course Policies**

**University Policies:**

**We are confident that graduate students are dedicated to learning and progressing toward a thesis research. We are required to include the following statement of university policies.**

**Student Accessibility Support Center Statement:**

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or at [sasc@stonybrook.edu](mailto:sasc@stonybrook.edu). They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center. For procedures and information go to the following website: <https://ehs.stonybrook.edu/programs/fire-safety/emergency-evacuation/evacuation-guide-people-physical-disabilities> and search Fire Safety and Evacuation and Disabilities.

**Academic Integrity Statement:**

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at [http://www.stonybrook.edu/commcms/academic\\_integrity/index.html](http://www.stonybrook.edu/commcms/academic_integrity/index.html)

**Important Note:** Any form of academic dishonesty, including cheating and plagiarism, will be reported to the Academic Judiciary.

**Critical Incident Management:**

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

**Course Policies:****Understand When You May Drop This Course:**

It is the student's responsibility to understand when they need to consider withdrawing from a

course. Refer to the Stony Brook Academic Schedule for dates and deadlines for registration: [http://www.stonybrook.edu/commcms/registrar/calendars/academic\\_calendars](http://www.stonybrook.edu/commcms/registrar/calendars/academic_calendars).

- [Undergraduate Course Load and Course Withdrawal Policy](#)
- [Graduate Course Changes Policy](#)

**Incomplete Policy:**

Under emergency/special circumstances, students may petition for an incomplete grade. Circumstances must be documented and significant enough to merit an incomplete. If you need to request an incomplete for this course, contact us for approval as far in advance as possible.

**Course Materials and Copyright Statement:**

Course material accessed from Blackboard, SB Connect, SB Capture or a Stony Brook Course website is for the exclusive use of students who are currently enrolled in the course. Content from these systems should not be reused or distributed without written permission of the instructor and/or the copyright holder. Duplication of materials protected by copyright, without permission of the copyright holder is a violation of the Federal copyright law, as well as a violation of Stony Brook's Academic Integrity.

**Online Communication Guidelines and Learning Resources:**

Maintain professional conduct both in the classroom and online. The classroom is a professional environment where academic debate and learning take place. I will make every effort to make this environment safe for you to share your opinions, ideas, and beliefs. In return, you are expected to respect the opinions, ideas, and beliefs of other students—both in the face-to-face classroom and online communication. Students have the right and privilege to learn in the class, free from harassment and disruption. The course follows the standards set in the Student Code of Conduct, and students are subject to disciplinary action for violation of that code. If your behavior does not follow the course etiquette standards stated below, the grade you receive for a posting may suffer. We reserve the right to remove any discussion messages that display inappropriate language or content.

**Online etiquette, as stated by the university administration:**

- Offensive language or rudeness will not be tolerated. Discuss ideas, not the person.
- Avoid cluttering your messages with excessive emphasis (stars, arrows, exclamations).
- If you are responding to a message, include the relevant part of the original message in your reply, or refer to the original post to avoid confusion;
- Be specific and clear, especially when asking questions.
- Use standard punctuation and capitalization. Using all UPPERCASE characters gives the appearance of shouting and makes the message less legible;
- Remember that not all readers have English as their native language, so make allowances for possible misunderstandings and unintended discourtesies.

**University Comments Concerning Online Classes**

It is important to remember that we will not have the non-verbal cues that occur in a face-to-face classroom. We cannot see the confused, frustrated, or unhappy expressions on your face if you encounter problems. You MUST communicate with us so that we can help. To make the experience go smoothly, remember that you're responsible for initiating more contact, and being direct, persistent, and vocal when you don't understand something.

Our Role as Instructors:

As the instructors, we will serve as a "guide" in our online classroom. While we may not respond to every post, we will read what is posted, and reply when necessary. Expect instructor posts in the following situations:

- To assist each of you when it comes to making connections between discussion, lectures, and textbook material.
- To fill in important things that may have been missed.
- To re-direct discussion when it gets "out of hand."
- To point out key points or to identify valuable posts.

**Part 6: Student Resources**

Amazon @ Stony Brook: Order your books before classes begin. Phone: 631-632-9828; email: Bookstore\_Liaison@stonybrook.edu; website: <http://www.stonybrook.edu/bookstore/>

Bursar: For help with billing and payment. Phone: 631-632-9316; email: bursar@stonybrook.edu; website: <http://www.stonybrook.edu/bursar/>

Career Center: The Career Center's mission is to support the academic mission of Stony Brook University by educating students about the career decision-making process, helping them plan and attain their career goals, and assisting with their smooth transition to the workplace or further education. Phone: 631-632-6810; email: sbucareercenter@stonybrook.edu; website: <http://www.stonybrook.edu/career-center/>

Counseling and Psychological Services: CAPS staff are available by phone, day or night. <http://studentaffairs.stonybrook.edu/caps/>

Ombuds Office: The Stony Brook University Ombuds Office provides an alternative channel for confidential, impartial, independent and informal dispute resolution services for the entire University community. We provide a safe place to voice your concerns and explore options for productive conflict management and resolution. The Ombuds Office is a source of confidential advice and information about University policies and procedures and helps individuals and groups address university-related conflicts and concerns. <http://www.stonybrook.edu/ombuds/>

Registrar: Having a registration issue? Let them know. Phone: 631-632-6175; email: registrar\_office@stonybrook.edu; <http://www.stonybrook.edu/registrar/>

SBU Libraries: access to and help in using databases, ebooks, and other sources for your research.

- Research Guides and Tutorials: <http://guides.library.stonybrook.edu/>
- Getting Help: <https://library.stonybrook.edu/research/ask-a-librarian/>

Student Accessibility Support Center: Students in need of special accommodations should contact SASC. Phone: 631-632-6748; email: sasc@stonybrook.edu; <https://www.stonybrook.edu/sasc/>

Support for Online Learning: <https://www.stonybrook.edu/online/>

Writing Center: Students are able to schedule face-to-face and online appointments. <https://www.stonybrook.edu/writingcenter/>