RELATIVITY (PHY 408) Fall 2022

[http://tonic.physics.stonybrook.edu/~syritsyn/phy408\_fall2022]

Course title: Relativity (PHY408)

Credit: 3 units

Semester: 2022 Fall

Instructor: Sergey Syritsyn (office C-140)

sergey.syritsyn[at]stonybrook.edu

Lectures: Melville Library E4315; 28 lectures starting Aug 23, TuTh 1:15–2:35PM

Office hours: In instructors' office (Physics C-140) or as announced; time/date TBA

Main textbooks (recommended reading):

1. B. Schutz, "A first course in general relativity"

(Main text for the course; new 3rd edition available in August 2022, but older editions are

acceptable)

2. J. Hartle,Gravity: "An introduction to Einstein's general relativity"

(Optional supplemental reading)

Course outline:

1. Review of Special relativity. Principles of special relativity. Minkowski space, Lorentz

transformations, invariant interval. Simultaneity, time dilation, space contraction, "paradoxes".

2. Relativistic mechanics. Vectors in special relativity. Relativistic velocity and accleleration,

energy and momentum. Proper time and connection to classical mechanics.

3. Tensors in Special relativity. Metric tensor, flat space in polar and spherical coordinates.

Relativistic fluids, pressure and stress tensors.

4. Curved space-time. Covariant derivative and Christoffel symbols. Curvature tensors. Motion

in weak fields.

5. Einstein field equations. General Einstein's gravity equations. Weak-field approximation.

6. Gravitational waves. Propagation, generation, and detection of gravitational waves.

7. Spherically-symmetric solutions. Static spherically symmetric solutions for perfect fluids;

gravitational fields of stars. Schwartzschild geometry, black holes and motion in their fields.

8. Cosmology. Cosmological models. Cosmological observations, dark matter, and dark energy.

Course grading

• Homeworks: 20%

• Midterms 1 and 2: 20% + 20%

• Final exam: 40%

Homeworks

Homeworks will be posted weekly on Tuesdays (Blackboard and/or course website), due in class

one week after posting. Late submissions will be deducted 20% of the grade per day. Model

solutions posted about five days after the due date. Discussions and group work are encouraged,

but each student will be expected to provide individually written solutions; noticeable similarities

will result in reduced grades.

Exams

• Midterm exams: Sep 29 and Nov 8 in class

• Final: Dec 13 (Tue) 2:15-5PM

Exams are open-book; no communication in/out of the class allowed. Students are encouraged to

compose one sheet of formula notes.

Student Accessibility Support Services (SASC):

If you have a physical, psychological, medical or learning disability that may impact your course

work, please contact Student Accessibility Support Center, ECC (Educational Communications

Center) Building, Room 128, (631)632-6748. They will determine with you what accommodations,

if any, are necessary and appropriate. All information and documentation is confidential.

https://www.stonybrook.edu/commcms/studentaffairs/sasc/facstaff/syllabus.php

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 is

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 schoolspecific 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

Critical Incident Management Statement

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.

**1. Review of Special relativity**

Principles of special relativity. Minkowski space, Lorentz transformations, invariant interval. Simultaneity, time dilation, space contraction, "paradoxes".

**2. Relativistic mechanics**

Vectors in special relativity. Relativistic velocity and accleleration, energy and momentum. Proper time and connection to classical mechanics.

**3. Tensors in Special relativity**

Metric tensor, flat space in polar and spherical coordinates. Relativistic fluids, pressure and stress tensors.

**4. Curved space-time**

Covariant derivative and Christoffel symbols. Curvature tensors. Motion in weak fields.

**5. Einstein field equation.**

General Einstein's gravity equations. Weak-field approximation.

**6. Gravitational waves**

Propagation, generation, and detection of gravitational waves.

**7. Spherically-symmetric solutions**

Static spherically symmetric solutions for perfect fluids; gravitational fields of stars. Schwartzschild geometry, black holes and motion in their fields.

**8. Cosmology**

Cosmological models. Cosmological observations, dark matter, and dark energy.