

STS-UY.3284 Relativity and Spacetime

Department of Technology, Culture and Society, NYU-Tandon

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Off. Hr: Tues 12:30-1:30pm remote, or by appt.
Office: 2Metrotech, 9th Fl., Rm929

Spring 2023 RH207
M/W 10:00-11:50am

I. Instructional Format: Instruction will be conducted in-class, unless circumstances require otherwise. Please be aware of the NYU policy on face masks at nyu.edu/life/safety-health-wellness/coronavirus-information/covid-related-guidance/protective-equipment.html. Masks are not required but welcome.

II. Description: This course is an introduction to the conceptual foundations of special and general relativity. In the first part of the course, we will develop the physics underlying special relativity and consider conceptual questions including: Does special relativity prohibit faster-than-light travel? Does it allow a traveling astronaut to age less and return home in the distant future? What is the significance of Einstein's famous equation $E = mc^2$? In the second part, we will develop the physics underlying general relativity and consider conceptual issues surrounding such current applications as time machines, wormholes, and black hole thermodynamics. This course is geared towards students with minimal background in mathematics, physics, or philosophy.

III. Objectives

HuSS (Humanities and Social Sciences) General Education Objectives

Think critically, creatively and independently; demonstrate information literacy; demonstrate skills in inquiry and analysis; demonstrate effective oral communication skills; demonstrate effective writing skills; bring the perspectives of HuSS to bear on technical discourse; demonstrate ethical reasoning.

STS (Science, Technology and Society) Cluster Objectives

- Demonstrate a basic understanding of the following:
 - How sci & tech shape society (in historical, philosophical, sociological, cultural, and technical ways).
 - How social processes frame sci and tech enterprises, including theory construction, invention, and innovation.
 - The relation between the content of sci/tech knowledge, and the social context in which it is created.
- Demonstrate technical proficiency in a field in the natural sciences or engineering.
- Demonstrate ability to critically analyze and communicate issues involving interactions among sci, tech, & society.

IV. Reading

A. At Bookstore or online via Bobst:

1. [Sar] Sartori, L. (1996) *Understanding Relativity*, Univ. California Press.

B. Online at course website:

2. [AM] Arntzenius, F. & T. Maudlin (2009), "Time Travel and Modern Physics", in E. Zalta (ed) *Stanford Encyclopedia of Philosophy*, plato.stanford.edu/entries/time-travel-phys.
3. [C] Curiel, E. (2019) "Singularities and Black Holes, in E. Zalta (ed) *Stanford Encyclopedia of Philosophy*, plato.stanford.edu/entries/spacetime-singularities.
4. [EWM] Earman, J., C. Wüthrich, J. Manchak (2020), "Time Machines", in E. Zalta (ed.) *Stanford Encyclopedia of Philosophy*, plato.stanford.edu/entries/time-machine.
5. [F] Flores, F. (2019), "The Equivalence of Mass and Energy", in E. Zalta (ed.) *Stanford Encyclopedia of Philosophy*, plato.stanford.edu/entries/equivME.
6. [J] Janis, A. (2018), "Conventionality of Simultaneity", in E. Zalta (ed.) *Stanford Encyclopedia of Philosophy*, plato.stanford.edu/entries/spacetime-convensimul.
7. [N] Norton, J. (2019), "The Hole Argument", in E. Zalta (ed.) *Stanford Encyclopedia of Philosophy*, plato.stanford.edu/entries/spacetime-holearg.
8. [Sav] Savitt, S. (2021), "Being and Becoming in Modern Physics", in E. Zalta (ed.) *Stanford Encyclopedia of Philosophy*, plato.stanford.edu/entries/spacetime-bebecome.

V. Requirements: This course has two websites: A Brightspace website, brightspace.nyu.edu, accessible only to enrolled students, and a public website, research.engineering.nyu.edu/~jbain/philrel.

1. **12 homework assignments.** These are posted in the Contents section in Brightspace. Please submit them by their due dates to links in the Brightspace Assignments folder. Your final homework grade will be calculated from the best 10 of your 12 assignment grades. Two optional extra credit assignments may also be submitted and will count towards your final homework grade.

Homework submission format: The preferred file type is .pdf. Please label the file you submit using the following format:

<assignment number>.<last name>_<first initial>.<file type>

Example: Mona Ashiya's .pdf submission for homework #7 should be labeled:

07.Ashiya_M.pdf

2. **One paper** of 5-7 pages (typed, 10- or 12-point, double-spaced, spell-checked!). Suggested topics are posted in the Contents section in Brightspace. The paper should conform to guidelines that are posted in the Contents section of Brightspace. Late paper policy: Late papers will be accepted up to the date of the final.
3. **One midterm** and **one final.** Each exam will consist of 8 short answer questions, of which you will be asked to pick 6 to respond to; and 3 short essay questions, of which you will be asked to pick 2 to respond to. A response to a short answer question should be no more than 1 paragraph in length (~3-4 sentences), and a response to a short essay question should be no more than 1 page in length (~3-4 paragraphs). Both the midterm and the final will be open-book, open-notes, take-home exams and should be submitted to the relevant link in the Brightspace Assignments folder. For the policy on makeup exams, please see Section VII.3.ii below.

VI. Grade Distribution: Homework: 25% total Midterm: 25% Paper: 20% Final: 30%

VII. Reminders on University Policies

1. **Inclusion Statement.** NYU values an inclusive and equitable environment for all students. I hope to foster a sense of community in this class and consider it a place where individuals of all backgrounds, beliefs, ethnicities, national origins, gender identities, sexual orientations, religious and political affiliations, and abilities will be treated with respect. It is my intent that all learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. If this standard is not being upheld, please feel free to speak with me.
2. **Moses Statement.** If you are student with a disability who is requesting accommodations, please contact the Moses Center for Students with Disabilities (CSD) at 212-998-4980, mosescsd@nyu.edu, nyu.edu/csd, 726 Broadway, 2nd Flr. You must be registered with CSD to receive accommodations.
3. **Standards and Procedures.** The NYU-Tandon Office of Student Affairs maintains a Community Standards and Procedures website at engineering.nyu.edu/life/student-affairs/community-standards-procedures. It contains information relevant to:
 - (i) Incompletes. It is NYU-Tandon policy that incompletes can be given only in extenuating circumstances (medical emergencies, accidents, etc.). An incomplete cannot be given because of a heavy course load, job commitments, or because you've simply fallen behind. For this reason, you should attend every lecture and make sure you're aware of assignment deadlines and exam dates. If you find yourself falling behind during the semester, do not hesitate to contact me. If you think you qualify for an incomplete grade at the end of the semester, see the procedure in (ii) below.
 - (ii) Excuses due to illness or circumstances. If you are experiencing an illness or any other situation that might affect your academic performance in a class (for instance, if you have to miss a lecture or an exam), please email Deanna Rayment, Coordinator of Student Advocacy, Compliance and Student Affairs, Dibner Hall Room LC 240C, eng.studentadvocate@nyu.edu. Deanna can reach out to your instructors on your behalf when warranted.
 - (iii) University Honor System. Please be aware of the university policy on cheating and plagiarism in the Student Code of Conduct. Cheating on an exam, or plagiarizing on an essay assignment, are sufficient reasons for receiving an F in the course. The Code of Conduct can be downloaded from the Office of Student Affairs website listed above.
4. **University Policy on Grading.** The following is NYU-Tandon's grading policy for all undergrad classes:

A	Excellent (4.0)	C+	Passing (2.3)	F	Failing (0.0)	AUD	Audit
A-	Excellent (3.7)	C	Passing (2.0)	S	Satisfactory	NR	Not Received
B+	Good (3.3)	C-	Deficient, but passing (1.7)	U	Unsatisfactory	P	Passing
B	Good (3.0)	D+	Deficient, but passing (1.3)	W	Withdrawal	MR	Must Repeat
B-	Good (2.7)	D	Deficient, but passing (1.0)	I	Incomplete		

VIII. Class Schedule.

The following schedule may be subject to revision over the course of the semester. Reading assignments should be completed by the date on which they appear.

1	Mon 1/23 <i>Pre-20th Cent Physics Survey</i>	Weds 1/25 <i>Survey, cont.</i> [Sar] Chap 1
2	1/30 <i>Special Relativity: Two Postulates</i> [Sar] Chap 2	2/1 <i>Michelson/Morely Experiment</i> hw1 due
3	2/6 <i>Simultaneity</i> [Sar] Chap. 3.1-3.3, Chap. 5.1-5.4	2/8 <i>Simultaneity, cont.</i> [J]. hw2 due
4	2/13 <i>Time Dilation, Length Contraction</i> [Sar] Chap. 3.4-3.9, 6.1-6.3, 6.5	2/15 <i>The Minkowski Metric</i> [Sar] Chap 4.1-4.4. hw3 due
5	2/20 NO CLASS (Presidents' Day)	2/22 <i>Dynamics: Momentum</i> [Sar] Chap. 7.1-7.8. hw4 due
6	2/27 <i>Dynamics: Energy.</i>	3/1 <i>Mass/Energy Equivalence</i> [F]. hw5 due
7	3/6 <i>Interpreting Special Relativity</i> [Sav].	3/8 <i>Interpreting SR, cont.</i> hw6 due
8	3/13 SPRING BREAK	3/15 SPRING BREAK
9	3/20 <i>Non-Euclidean Geometry</i> [Sar] Chap. 8.5.	3/22 <i>Non-Euclidean Geometry, cont.</i> hw7 due; Midterm handed out
10	3/27 <i>Geometrization of Gravity</i> [Sar] Chap. 8.1-8.4.	3/29 <i>Principle of Equivalence</i> [Sar] Chap. 8.6. Midterm due
11	4/3 <i>Conventionality of Geometry & Einstein Equations</i>	4/5 <i>Interpreting GR: Mach's Principle</i> [Sar] Chap. 9.1-9.3. hw8 due
12	4/10 <i>Interpreting GR: The Hole Argument</i> [N].	4/12 <i>The Horizon Problem</i> [Sar] Chap. 9.4-9.9. hw9 due
13	4/17 <i>Black Holes and Singularities</i> [C].	4/19 <i>The Cosmic Censorship Conjecture</i> hw10 due
14	4/24 <i>Black Hole Thermodynamics</i>	4/26 <i>Time Travel</i> [AM]. hw11 due
15	5/1 <i>Time Machines</i> [EWM].	5/3 <i>Time Machines, cont.</i> hw12 due
16	5/8 <i>Time Machine Spacetimes</i> Paper due; Final handed out	