

PHYSICS

Departmental Office: 704 Pupin; 212-854-3348
<http://www.columbia.edu/cu/physics>

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 212-854-3969; jeremy.dodd@columbia.edu

The physics major offers a rigorous preparation in the intellectual developments of modern physics, along with extensive exposure to the mathematical and experimental techniques required to conduct basic and applied research in physics.

For the major, the department offers a set of required courses well-suited to prepare students for the most rigorous course of graduate study. These can be supplemented by elective courses in a variety of advanced topics. Although most majors go on to graduate work in physics, the intellectual skills acquired in the study of physics can also provide the basis for work in a variety of other scientific and nonscientific areas.

The physics concentration is for students who are interested in physics but are uncertain about graduate study in physics; for those who want to explore other subjects along with physics; for those who want to find a physics- or technology-related job after graduation; or for those who are considering a professional school such as law or medicine. The department helps concentrators custom design programs to ensure maximum flexibility in meeting students' intellectual needs and career goals. With appropriate selection of courses, the concentrator can explore other subjects yet maintain the option of graduate study in physics.

Research is an extremely important component of the Columbia physics experience. Because the department has a very small student-to-faculty ratio, essentially all physics majors and concentrators engage in experimental, computational, or theoretical research under the close supervision of a faculty member during part, if not all, of their time at Columbia.

Registration for Introductory Courses

The department offers a stand-alone one-semester course for nonscience majors, one introductory sequence in physics intended primarily for preprofessional students, and three introductory sequences in physics for engineering and physical science majors. Students are given credit for courses from only one of the different sequence groups.

Mixing courses across the sequences is strongly discouraged; however, physics majors who begin their studies with PHYS UN1401 Introduction To Mechanics and Thermodynamics - PHYS UN1402 INTRO ELEC/MAGNETISM # OPTCS should take PHYS UN2601 Physics, III: Classical and Quantum Waves as the third-semester course.

Introductory Sequences

Nonscience Majors:

PHYS UN1001 Physics for Poets

Preprofessional Students:

PHYS UN1201 General Physics I
 - PHYS UN1202 and General Physics II

Accompanying laboratory course:

PHYS UN1291 General Physics Laboratory
 - PHYS UN1292 and General Physics Laboratory II

Engineering and Physical Science Majors:

Select one of the following sequences with accompanying laboratory course:

Sequence A:

PHYS UN1401	Introduction To Mechanics and
- PHYS UN1402	Thermodynamics
- PHYS UN1403	and INTRO ELEC/MAGNETISM # OPTCS
	and Introduction to Classical and
	Quantum Waves

Sequence B:

PHYS UN1601	Physics, I: Mechanics and Relativity
- PHYS UN1602	and Physics, II: Thermodynamics,
- PHYS UN2601	Electricity, and Magnetism
	and Physics, III: Classical and Quantum
	Waves

Sequence C:

PHYS UN2801	Accelerated Physics I
- PHYS UN2802	and Accelerated Physics II

Sequence A is a self-contained group of three courses, while Sequences B and C anticipate more course work in the Physics Department.

Students considering a physics major are strongly encouraged to begin one of these sequences in their first year.

Laboratory

Many of the introductory courses include a laboratory, as indicated. A \$75 per term *laboratory fee* is charged for all 1000-level and 2000-level laboratories.

Advanced Placement

Students may earn a maximum of 6 credits in physics. The department grants 6 credits for a score of 4 or 5 on the AP Physics B exam, but the student is not entitled to any exemptions. The amount of credit is reduced to 3 if the student takes a 1000-level physics course.

The department grants 3 credits for a score of 4 or 5 on the AP Physics C/MECH exam, but the student is not entitled to any exemptions. The amount of credit is reduced to 0 if the student takes PHYS UN1001, PHYS UN1201, PHYS UN1401 or PHYS UN1601.

The department grants 3 credits for a score of 4 or 5 on the AP Physics C/E&M exam, but the student is not entitled to any exemptions. The amount of credit is reduced to 0 if the student takes PHYS UN1001, PHYS UN1202, PHYS UN1402 or PHYS UN1602.

Professors

Igor Aleiner
 Boris Altshuler
 Elena Aprile
 Dmitri Bassov
 Andrei Beloborodov
 Allan Blaer (*emeritus*)
 Gustaaf Brooijmans
 Norman Christ
 Brian Cole
 Frederik Deneff
 Richard Friedberg (*Barnard emeritus*)
 Brian Greene (Mathematics)
 Miklos Gyulassy (*emeritus*)
 Charles J. Hailey
 Timothy Halpin-Healy (Barnard)
 Sven Hartmann (*emeritus*)

Tony Heinz (*emeritus*)
 Emlyn Hughes
 Lam Hui
 Laura Kay (Barnard Astronomy)
 Tsung Dao Lee (*emeritus*)
 Yuri Levin
 Szabolcs Marka
 Robert Mawhinney (Chair)
 Andrew Millis
 Alfred H. Mueller
 Reshmi Mukherjee (Barnard)
 John Parsons
 Aron Pinczuk (Applied Physics)
 Malvin Ruderman
 Frank Sciulli (*emeritus*)
 Michael Shaevitz
 Michael Tuts
 Yasutomo Uemura
 Erick Weinberg
 William Zajc

Associate Professors

Brian Humensky
 Janna Levin (Barnard)
 Brian Metzger
 Alberto Nicolis
 Abhay Pasupathy
 Ozgur Sahin (Biology)
 Tanya Zelevinsky

Assistant Professors

Cory Dean
 Bradley Johnson
 Georgia Karagiorgi
 Rachel Rosen
 Sebastian Will

Senior Lecturer in Discipline

Jeremy Dodd

Adjunct Professor

Morgan May

Lecturer

Burton Budick
 Eric Raymer

On Leave

Amber Miller

Guidelines for all Physics Majors, Concentrators, and Interdepartmental Majors

Majors and concentrators should plan their programs of study with the director of undergraduate studies before the beginning of the junior year.

Prospective physics majors are strongly encouraged to begin one of the introductory physics sequences in their first year. Majors should aim to acquire as extensive a background in mathematics as possible.

The department considers laboratory experience to be an essential part of the physics curriculum. Majors and concentrators can gain such experience in the intermediate-level laboratories, the electronics laboratory, and through experimental research in faculty research groups.

Grading

A grade of C- or better must be obtained for a course to count toward the majors or the concentration. The grade of P is not acceptable, but a course that was taken P/D/F may be counted if and only if the P is uncovered by the Registrar's deadline.

Major in Physics

Physics Courses

The major in physics requires a minimum of 41 points in physics courses, including:

Introductory Sequences

Select one of the following sequences:

Sequence A: Students with a limited background in high school physics may elect to take:

PHYS UN1401 - PHYS UN1402 - PHYS UN2601	Introduction To Mechanics and Thermodynamics and INTRO ELEC/MAGNETISM # OPTCS and Physics, III: Classical and Quantum Waves
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Sequence B:

PHYS UN1601 - PHYS UN1602 - PHYS UN2601	Physics, I: Mechanics and Relativity and Physics, II: Thermodynamics, Electricity, and Magnetism and Physics, III: Classical and Quantum Waves
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Sequence C: Students with advanced preparation in both physics and mathematics may be eligible to take:

PHYS UN2801 - PHYS UN2802	Accelerated Physics I and Accelerated Physics II
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Core Physics Courses

PHYS UN3003	Mechanics
PHYS UN3007	Electricity and Magnetism
PHYS UN3008	Electromagnetic Waves and Optics
PHYS GU4021	Quantum Mechanics I
PHYS GU4022	Quantum Mechanics II
PHYS GU4023	Thermal and Statistical Physics

Elective Courses

Select at least six points of the following courses:

PHYS UN3002	From Quarks To the Cosmos: Applications of Modern Physics
PHYS GU4003	Advanced Mechanics
PHYS GU4011	Particle Astrophysics and Cosmology
PHYS GU4018	Solid-State Physics
PHYS GU4019	Mathematical Methods of Physics
PHYS GU4040	Introduction to General Relativity
PHYS GU4050	Introduction to Particle Physics

With the permission of the Director of Undergraduate Studies, 4000- or 6000-level courses offered in this or other science departments

Laboratory Work at the Intermediate Level*

Select one of the following options:

Option 1:	
PHYS UN3081	Intermediate Laboratory Work (two semesters)
PHYS UN3083	Electronics Laboratory
Option 2:	
PHYS UN3081	Intermediate Laboratory Work (three semesters)
Senior Seminar	
PHYS UN3072	Seminar in Current Research Problems

* Approved experimental work with a faculty research group may satisfy one semester of the laboratory requirement.

Mathematics Courses

Calculus through MATH UN1202 CALCULUS IV or MATH UN1208 HONORS MATHEMATICS B; and MATH UN3027 Ordinary Differential Equations or the equivalent.

Recommended cognate courses: MATH UN2010 LINEAR ALGEBRA, MATH UN3007 Complex Variables, and MATH UN3028 PARTIAL DIFFERENTIAL EQUATIONS.

Concentration in Physics

The concentration in physics requires a minimum of 24 points in physics, including one of the introductory sequences.

Interdisciplinary Major

It is also possible to major in astrophysics, biophysics, and chemical physics. Students interested in these areas should consult with the director of undergraduate studies and with cognate departments (astronomy, biological sciences, chemistry).

For astrophysics requirements please see:

<http://bulletin.columbia.edu/columbia-college/departments-instruction/astronomy/#requirementstext>

For biophysics requirements please see:

<http://bulletin.columbia.edu/columbia-college/departments-instruction/biological-sciences/#requirementstext>

For chemical physics requirements please see:

<http://bulletin.columbia.edu/columbia-college/departments-instruction/chemistry/#requirementstext>

PHYS UN1001 Physics for Poets. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: high school algebra.

This course does not fulfill the physics requirement for admission to medical school. No previous background in physics is expected. An introduction to physics taught through the exploration of the scientific method, and the application of physical principles to a wide range of topics from quantum mechanics to cosmology.

Spring 2021: PHYS UN1001

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1001	001/10222	M W 2:40pm - 3:55pm Online Only	Szabolcs Marka	3	92/150

PHYS UN1018 Weapons of Mass Destruction. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: high school science and math.

A review of the history and environmental consequences of nuclear, chemical, and biological weapons of mass destruction (WMD); of how these weapons work, what they cost, how they have spread, how they might be used, how they are currently controlled by international treaties and domestic legislation, and what issues of policy and technology arise in current debates on WMD. What aspects of the manufacture of WMD are easily addressed, and what aspects are technically challenging? It may be expected that current events/headlines will be discussed in class.

PHYS UN1111 Origins and Meaning. 3 points.

This course is a one-semester journey across cosmological history, from the beginning of time to something akin to its end. We will explore the origin of inanimate physical structures (the cosmos as a whole, as well as that of galaxies, stars, planets, particles, atoms and complex molecules), the origin of life (replicating molecules, the first cells, as well as more complex life forms), the origin of mind (self-reflective conscious awareness) and the origin of culture (language, myth, religion, art, and science). We will then consider what science in particular tells us about the very far future, where we will encounter the likely demise of all complex matter, all life and all consciousness. In the face of such disintegration we will examine the nature of value and purpose. We will recognize that the deepest understanding of reality emerges from blending all of the accounts we discuss—from the reductionist to the humanist to the cosmological—and only through such amalgamation can we fully grasp the long-standing human search for meaning.

Fall 2021: PHYS UN1111

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1111	001/11929	F 2:10pm - 5:00pm Room TBA	Brian Greene	3	165/150

PHYS UN1201 General Physics I. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: some basic background in calculus or be concurrently taking MATH UN1101 Calculus I., The accompanying laboratory is PHYS UN1291-UN1292

The course will use elementary concepts from calculus. The accompanying laboratory is *PHYS UN1291 - UN1292*. Basic introduction to the study of mechanics, fluids, thermodynamics, electricity, magnetism, optics, special relativity, quantum mechanics, atomic physics, and nuclear physics.

Spring 2021: PHYS UN1201

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1201	001/10189	T Th 5:40pm - 6:55pm Online Only	P. Michael Tuts	3	139/200

Fall 2021: PHYS UN1201

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1201	001/11931	M W 10:10am - 11:25am Room TBA	Michael Shaevitz	3	156/180
PHYS 1201	002/11932	T Th 5:40pm - 6:55pm Room TBA	P. Michael Tuts	3	85/180

PHYS UN1202 General Physics II. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: This course will use elementary concepts from calculus. Students should therefore have had some high school calculus, or be concurrently enrolled in MATH UN1101. Taken with accompanying lab PHYS UN1291- PHYS UN1292, the sequence PHYS UN1201- PHYS UN1202 satisfies requirements for medical school. Electricity, magnetism, optics, and modern physics.

Spring 2021: PHYS UN1202

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1202	001/10190	M W 10:10am - 11:25am Online Only	Michael Shaevitz	3	147/200
PHYS 1202	002/12972	M W 5:40pm - 6:55pm Online Only	Eric Raymer	3	113/120

Summer 2021: PHYS UN1202

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1202	002/11140	M W 6:15pm - 7:30pm Online Only	Rebecca Grossman	3	54/70

PHYS UN1291 General Physics Laboratory. 1 point.Same course as *PHYS W1291x*, but given off-sequence.

Corequisites: PHYS UN1201

This course is the laboratory for the corequisite lecture course and can be taken only during the same term as the corresponding lecture.

Spring 2021: PHYS UN1291

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1291	001/10191	M 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	14/15
PHYS 1291	002/10192	M 4:10pm - 7:10pm Online Only	Giuseppina Cambareri	1	11/15
PHYS 1291	003/10193	T 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	14/15
PHYS 1291	004/10194	T 7:30pm - 10:30pm Online Only	Giuseppina Cambareri	1	11/15
PHYS 1291	005/10195	W 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	10/15
PHYS 1291	006/10196	W 4:10pm - 7:10pm Online Only	Giuseppina Cambareri	1	10/15
PHYS 1291	007/10197	Th 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	11/15
PHYS 1291	008/10198	M 7:30pm - 10:30pm Online Only	Giuseppina Cambareri	1	7/15
PHYS 1291	010/18017	F 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	13/15

Fall 2021: PHYS UN1291

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1291	001/11977	M 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	002/11978	M 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	003/11979	M 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	004/11980	M 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	6/15
PHYS 1291	005/11981	M 7:30pm - 10:30pm Room TBA	Giuseppina Cambareri	1	7/15
PHYS 1291	007/11982	T 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	008/11983	T 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	009/11984	T 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	6/15
PHYS 1291	010/11985	T 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	0/15
PHYS 1291	011/11986	T 7:30pm - 10:30pm Room TBA	Giuseppina Cambareri	1	6/15
PHYS 1291	013/11988	W 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	014/11989	W 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	015/11990	W 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	7/15
PHYS 1291	016/11991	W 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	1/15
PHYS 1291	017/11992	W 7:30pm - 10:30pm Room TBA	Giuseppina Cambareri	1	1/15
PHYS 1291	019/11993	Th 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	020/11994	Th 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	7/15
PHYS 1291	021/11995	Th 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	8/15
PHYS 1291	022/11996	Th 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	1	2/15
PHYS 1291	023/11997	Th 7:30pm - 10:30pm Room TBA	Giuseppina Cambareri	1	6/15
PHYS 1291	025/11998	F 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	15/15
PHYS 1291	026/12000	F 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	1	8/15

PHYS UN1292 General Physics Laboratory II. 1 point.

Corequisites: PHYS UN1201, PHYS UN1202

This course is the laboratory for the corequisite lecture course (*PHYS UN1201 - PHYS UN1202*) and can be taken only during the same term as the corresponding lecture.

Spring 2021: PHYS UN1292

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1292	001/10199	M 1:00pm - 4:00pm Online Only		1	15/15
PHYS 1292	002/16491	M 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	15/15
PHYS 1292	007/10202	T 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	008/16493	T 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	009/10203	T 4:10pm - 7:10pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	010/16494	T 4:10pm - 7:10pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	011/10204	T 7:30pm - 10:30pm Online Only	Giuseppina Cambareri	1	14/15
PHYS 1292	013/10205	W 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	14/15
PHYS 1292	014/16495	W 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	015/10206	W 4:10pm - 7:10pm Online Only	Giuseppina Cambareri	1	15/15
PHYS 1292	017/10207	W 7:30pm - 10:30pm Online Only	Giuseppina Cambareri	1	12/15
PHYS 1292	018/10208	Th 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	14/15
PHYS 1292	019/16497	Th 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	020/10209	Th 4:10pm - 7:10pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	022/10210	Th 7:30pm - 10:30pm Online Only	Giuseppina Cambareri	1	13/15
PHYS 1292	023/10211	F 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	12/15

Summer 2021: PHYS UN1292

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1292	001/10291	M 1:00pm - 4:10pm Online Only	Giuseppina Cambareri	1	15/15
PHYS 1292	002/11142	T 1:00pm - 4:10pm Online Only	Giuseppina Cambareri	1	15/15
PHYS 1292	003/11143	W 1:00pm - 4:10pm Online Only	Giuseppina Cambareri	1	15/15
PHYS 1292	004/11144	Th 1:00pm - 4:10pm Online Only	Giuseppina Cambareri	1	15/15
PHYS 1292	009/12941	W 1:00pm - 4:00pm Online Only	Giuseppina Cambareri	1	3/15

PHYS UN1401 Introduction To Mechanics and Thermodynamics. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Corequisites: MATH UN1101

Fundamental laws of mechanics, kinematics and dynamics, work and energy, rotational dynamics, oscillations, gravitation, fluids, temperature and heat, gas laws, the first and second laws of thermodynamics.

Corequisite: MATH UN1101 or the equivalent.

Spring 2021: PHYS UN1401

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1401	001/10213	T Th 10:10am - 11:25am Online Only	Emlyn Hughes	3	82/200

Fall 2021: PHYS UN1401

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1401	001/11935	M W 1:10pm - 2:25pm Room TBA	Jeremy Dodd	3	22/160
PHYS 1401	002/11937	T Th 10:10am - 11:25am Room TBA	Tanya Zelevinsky	3	12/160

PHYS UN1402 INTRO ELEC/MAGNETISM # OPTCS. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: PHYS UN1401

Corequisites: MATH UN1102

Prerequisites: PHYS W1401. Corequisites: MATH V1102 or the equivalent. Electric fields, direct currents, magnetic fields, alternating currents, electromagnetic waves, polarization, geometrical optics, interference, and diffraction

Spring 2021: PHYS UN1402

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1402	001/10212	T Th 10:10am - 11:25am Online Only	Georgia Karagiorgi	3.00	188/200

PHYS UN1403 Introduction to Classical and Quantum Waves. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: PHYS UN1402 *PHYS W1402*.Corequisites: *MATH V1201* or the equivalent.

Classical waves and the wave equation, Fourier series and integrals, normal modes, wave-particle duality, the uncertainty principle, basic principles of quantum mechanics, energy levels, reflection and transmission coefficients, applications to atomic physics.

Fall 2021: PHYS UN1403

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1403	001/11938	M W 11:40am - 12:55pm Room TBA	Yasutomo Uemura	3	119/150

PHYS UN1493 Introduction to Experimental Physics. 3 points.

Prerequisites: PHYS UN1401 and PHYS UN1402

Laboratory work associated with the two prerequisite lecture courses.

Experiments in mechanics, thermodynamics, electricity, magnetism, optics, wave motion, atomic physics, and nuclear physics. Note: Students cannot receive credit for both *PHYS UN1493* and *UN1494*.

PHYS UN1494 Introduction to Experimental Physics. 3 points.

Prerequisites: PHYS UN1401 and PHYS UN1402

Laboratory work associated with the prerequisite lecture course.

Experiments in mechanics, thermodynamics, electricity, magnetism, optics, wave motion, atomic physics, and nuclear physics.

Spring 2021: PHYS UN1494

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1494	001/10214	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	11/12
PHYS 1494	001/10214	T 4:10pm - 7:10pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	11/12
PHYS 1494	002/10215	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	13/12
PHYS 1494	002/10215	T 7:30pm - 10:30pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	13/12
PHYS 1494	003/10216	W 1:00pm - 4:00pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	13/12
PHYS 1494	003/10216	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	13/12
PHYS 1494	004/10217	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	11/12
PHYS 1494	004/10217	W 4:10pm - 7:10pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	11/12
PHYS 1494	005/10218	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	9/12
PHYS 1494	005/10218	W 7:30pm - 10:30pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	9/12
PHYS 1494	006/10219	Th 1:00pm - 4:00pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	12/12
PHYS 1494	006/10219	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	12/12
PHYS 1494	007/10220	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	9/12
PHYS 1494	007/10220	Th 4:10pm - 7:10pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	9/12
PHYS 1494	008/10221	F 1:00pm - 4:00pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	10/12
PHYS 1494	008/10221	T 3:00pm - 3:55pm Online Only	Giuseppina Cambareri, Guanhao Sun	3	10/12

Fall 2021: PHYS UN1494

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1494	001/12001	T 3:00pm - 3:55pm Room TBA	Giuseppina Cambareri	3	15/15
PHYS 1494	001/12001	T 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	3	15/15
PHYS 1494	002/12002	T 3:00pm - 3:55pm Room TBA	Giuseppina Cambareri	3	4/15
PHYS 1494	002/12002	T 7:30pm - 10:30pm Room TBA	Giuseppina Cambareri	3	4/15
PHYS 1494	003/12003	W 1:00pm - 4:00pm Room TBA	Giuseppina Cambareri	3	15/15
PHYS 1494	003/12003	T 3:00pm - 3:55pm Room TBA	Giuseppina Cambareri	3	15/15
PHYS 1494	004/12004	T 3:00pm - 3:55pm Room TBA	Giuseppina Cambareri	3	14/15
PHYS 1494	004/12004	W 4:10pm - 7:10pm Room TBA	Giuseppina Cambareri	3	14/15
PHYS 1494	005/12005	T 3:00pm - 3:55pm	Giuseppina	3	10/15

PHYS UN1601 Physics, I: Mechanics and Relativity. 3.5 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: Corequisite: MATH UN1102 Calculus II or equivalent. Fundamental laws of mechanics, kinematics and dynamics, work and energy, rotational dynamics, oscillations, gravitation, fluids, introduction to special relativity and relativistic kinematics. The course is preparatory for advanced work in physics and related fields.

Spring 2021: PHYS UN1601

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1601	001/10224	T Th 10:10am - 11:25am Online Only	Brian Cole	3.5	14/180

Fall 2021: PHYS UN1601

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1601	001/11939	T Th 10:10am - 11:25am Room TBA	Brian Cole	3.5	9/150

PHYS UN1602 Physics, II: Thermodynamics, Electricity, and Magnetism. 3.5 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: PHYS UN1601 Corequisite: MATH UN1201 or equivalent. Temperature and heat, gas laws, the first and second laws of thermodynamics, kinetic theory of gases, electric fields, direct currents, magnetic fields, alternating currents, electromagnetic waves. The course is preparatory for advanced work in physics and related fields.

Spring 2021: PHYS UN1602

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 1602	001/10223	T Th 10:10am - 11:25am Online Only	Jeremy Dodd	3.5	175/200

PHYS UN2001 Special Relativity. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: a working knowledge of high school algebra, trigonometry, and physics. Some familiarity with calculus is useful but not essential. This course is a comprehensive, one-semester introduction to the essential ideas and mathematical structures underlying Einstein's Special Theory of Relativity. Among the topics covered will be: the relativity of simultaneity, time dilation, Lorentz contraction, velocity combination laws, time dilation over large distances, the Lorentz transformation, spacetime diagrams, the basic (seeming) paradoxes of special relativity, relativistic equations of motion and $E = mc^2$.

PHYS UN2601 Physics, III: Classical and Quantum Waves. 3.5 points.

Prerequisites: PHYS UN1402 or PHYS UN1602 Corequisite: MATH UN1202 or equivalent.

Classical waves and the wave equation, geometrical optics, interference and diffraction, Fourier series and integrals, normal modes, wave-particle duality, the uncertainty principle, basic principles of quantum mechanics, energy levels, reflection and transmission coefficients, the harmonic oscillator. The course is preparatory for advanced work in physics and related fields.

Fall 2021: PHYS UN2601

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 2601	001/11940	M W 2:40pm - 3:55pm Room TBA	Szabolcs Marka	3.5	80/100

PHYS UN2699 Experiments in Classical and Modern Physics. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: (PHYS UN1601 or PHYS UN1401) and (PHYS UN1602 or PHYS UN1402) and PHYS UN2601 *PHYS W1601* (or *W1401*), *W1602* (or *W1402*), and *W2601*.

Laboratory work associated with the three prerequisite lecture courses. Experiments in mechanics, thermodynamics, electricity, magnetism, optics, wave motion, atomic physics, and nuclear physics.

PHYS UN2801 Accelerated Physics I. 4.5 points.

Prerequisites: Advanced Placement in physics and mathematics, or the equivalent, and the instructor's permission. (A special placement meeting is held during Orientation.)

This accelerated two-semester sequence covers the subject matter of *PHYS UN1601*, *PHYS UN1602* and *PHYS UN2601*, and is intended for those students who have an exceptionally strong background in both physics and mathematics. The course is preparatory for advanced work in physics and related fields. There is no accompanying laboratory; however, students are encouraged to take the intermediate laboratory, *PHYS UN3081*, in the following year.

Fall 2021: PHYS UN2801

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 2801	001/11941	T Th 10:10am - 12:00pm Room TBA	Norman Christ	4.5	2/100

PHYS UN2802 Accelerated Physics II. 4.5 points.

Prerequisites: PHYS UN2801

This accelerated two-semester sequence covers the subject matter of *PHYS UN1601*, *PHYS UN1602* and *PHYS UN2601*, and is intended for those students who have an exceptionally strong background in both physics and mathematics. The course is preparatory for advanced work in physics and related fields. There is no accompanying laboratory; however, students are encouraged to take the intermediate laboratory, *PHYS UN3081*, in the following year.

Spring 2021: PHYS UN2802

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 2802	001/10225	T Th 10:10am - 12:00pm Online Only	Norman Christ	4.5	32/70

PHYS UN2804 Disc Section Accelerated Physics II. 0 points.

Required discussion section for PHYS UN2802 Accelerated Physics II.

Spring 2021: PHYS UN2804

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 2804	001/17325	W 5:10pm - 6:00pm Online Only	Norman Christ	0	6/25
PHYS 2804	002/17326	F 10:10am - 11:00am Online Only	Norman Christ	0	8/25

PHYS UN3002 From Quarks To the Cosmos: Applications of Modern Physics. 3.5 points.

Not offered during 2021-22 academic year.

Prerequisites: PHYS UN2601 or PHYS UN2802

This course reinforces basic ideas of modern physics through applications to nuclear physics, high energy physics, astrophysics and cosmology. The ongoing Columbia research programs in these fields are used as practical examples. The course is preparatory for advanced work in physics and related fields.

PHYS UN3003 Mechanics. 3 points.

Prerequisites: general physics, and differential and integral calculus. Newtonian mechanics, oscillations and resonance, conservative forces and potential energy, central forces, non-inertial frames of reference, rigid body motion, an introduction to Lagrange's formulation of mechanics, coupled oscillators, and normal modes.

Spring 2021: PHYS UN3003

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3003	001/10226	M W 10:10am - 11:25am Online Only	John Parsons	3	48/70

PHYS UN3007 Electricity and Magnetism. 3 points.

Prerequisites: general physics, and differential and integral calculus. Electrostatics and magnetostatics, Laplace's equation and boundary-value problems, multipole expansions, dielectric and magnetic materials, Faraday's law, AC circuits, Maxwell's equations, Lorentz covariance, and special relativity.

Fall 2021: PHYS UN3007

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3007	001/11942	M W 11:40am - 12:55pm Room TBA	Alfred Mueller, Giuseppina Cambareri	3	33/100

PHYS UN3008 Electromagnetic Waves and Optics. 3 points.

Prerequisites: PHYS UN3008

Maxwell's equations and electromagnetic potentials, the wave equation, propagation of plane waves, reflection and refraction, geometrical optics, transmission lines, wave guides, resonant cavities, radiation, interference of waves, and diffraction.

Spring 2021: PHYS UN3008

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3008	001/10227	M W 11:40am - 12:55pm 428 Pupin Laboratories	Alfred Mueller, Giuseppina Cambareri	3	55/70

PHYS UN3072 Seminar in Current Research Problems. 2 points.

May be taken for Pass/Fail credit only.

A detailed study of a selected field of active research in physics. The motivation, techniques, and results obtained to the present, as well as the difficulties and unsolved problems. For Physics majors only. Priority given to seniors; juniors by permission of the instructor.

Spring 2021: PHYS UN3072

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3072	001/10228	T 4:10pm - 5:25pm 412 Pupin Laboratories	Georgia Karagiorgi	2	9/40

PHYS UN3081 Intermediate Laboratory Work. 2 points.

May be repeated for credit by performing different experiments. The laboratory has available fifteen individual experiments, of which two are required per 2 points.

Prerequisites: phys UN2601 or phys UN2802 Primarily for junior and senior physics majors; other majors must obtain the instructor's permission.

Each experiment is chosen by the student in consultation with the instructor. Each section meets one afternoon per week, with registration in each section limited by the laboratory capacity. Experiments (classical and modern) cover topics in electricity, magnetism, optics, atomic physics, and nuclear physics.

Spring 2021: PHYS UN3081

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3081	002/10230	Th 1:10pm - 5:00pm 6th Flr Pupin Laboratories	Morgan May	2	2/12
PHYS 3081	003/10231	F 1:10pm - 5:00pm 6th Flr Pupin Laboratories	Morgan May	2	5/12

Fall 2021: PHYS UN3081

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3081	001/11943	M 1:10pm - 5:00pm Room TBA	Cory Dean	2	10/10
PHYS 3081	002/11944	Th 1:10pm - 5:00pm Room TBA	Elena Aprile	2	8/10
PHYS 3081	003/11945	F 1:10pm - 5:00pm Room TBA	Morgan May	2	15/15

PHYS UN3083 Electronics Laboratory. 3 points.

Enrollment limited to the capacity of the laboratory.

Prerequisites: PHYS UN3003 or PHYS UN3007 May be taken before or concurrently with this course.

A sequence of experiments in solid-state electronics, with introductory lectures.

Spring 2021: PHYS UN3083

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3083	001/10232	M W 1:10pm - 4:00pm 329 Pupin Laboratories	John Parsons	3	7/12

PHYS UN3500 Supervised Readings in Physics. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: the written permission of the faculty member who agrees to act as supervisor, and the director of undergraduate studies' permission.

Readings in a selected field of physics under the supervision of a faculty member. Written reports and periodic conferences with the instructor.

Spring 2021: PHYS UN3500

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3500	001/10233		Jeremy Dodd	3	1/20

Fall 2021: PHYS UN3500

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3500	001/11946		Jeremy Dodd	3	0/3

PHYS UN3900 Supervised Individual Research. 1-5 points.

Prerequisites: the written permission of the faculty member who agrees to act as supervisor, and the director of undergraduate studies' permission.

For specially selected physics majors, the opportunity to do a research project in contemporary physics under the supervision of a faculty member. A detailed report on the research is presented by the student when the project is completed.

Spring 2021: PHYS UN3900

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3900	001/10234		Jeremy Dodd	1-5	7/20

Fall 2021: PHYS UN3900

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 3900	001/11947		Jeremy Dodd	1-5	2/20

PHYS GU4003 Advanced Mechanics. 3 points.

Prerequisites: differential and integral calculus, differential equations, and PHYS UN3003 or the equivalent.

Lagrange's formulation of mechanics, calculus of variations and the Action Principle, Hamilton's formulation of mechanics, rigid body motion, Euler angles, continuum mechanics, introduction to chaotic dynamics.

Spring 2021: PHYS GU4003

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 4003	001/10235	M W 4:10pm - 5:25pm Online Only	James Hill	3	24/45

PHYS GU4011 Particle Astrophysics and Cosmology. 3 points.

Prerequisites: (PHYS UN1403 or PHYS UN2601 or PHYS UN2802) and (MATH UN1202 or MATH UN1208) students are recommended but not required to have taken PHYS UN3003 and PHYS UN3007.

An introduction to the basics of particle astrophysics and cosmology. Particle physics - introduction to the Standard Model and supersymmetry/higher dimension theories; Cosmology – Friedmann-Robertson-Walker line element and equation for expansion of universe; time evolution of energy/matter density from the Big Bang; inflationary cosmology; microwave background theory and observation; structure formation; dark energy; observational tests of geometry of universe and expansion; observational evidence for dark matter; motivation for existence of dark matter from particle physics; experimental searches of dark matter; evaporating and primordial black holes; ultra-high energy phenomena (gamma-rays and cosmic-rays).

PHYS GU4012 String Theory. 3 points.

Prerequisites: PHYS UN3003 and PHYS UN3008 and PHYS GU4021 .

PHYS GU4023 would be helpful but is not required. Students should have some familiarity with tools for graphical presentation and numeric problem solving such as Mathematica and/or MatLab.

This course is intended as an introduction to string theory for undergraduates. No advanced graduate-level preparation is assumed, and the material will be covered at (no higher than) the advanced undergraduate level. Advanced topics such as supersymmetry, T-duality, and covariant quantization will not be covered. The focus will be on the dynamics of classical and quantum mechanical strings, with an emphasis on integrating undergraduate material in classical mechanics, relativity, electrodynamics and quantum mechanics.

PHYS GU4018 Solid-State Physics. 3 points.

Prerequisites: PHYS GU4021 and PHYS GU4023 or the equivalent.
Introduction to solid-state physics: crystal structures, properties of periodic lattices, electrons in metals, band structure, transport properties, semiconductors, magnetism, and superconductivity.

Spring 2021: PHYS GU4018

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 4018	001/10236	T Th 2:40pm - 3:55pm Online Only	Aron Pinczuk	3	10/30

PHYS GU4019 Mathematical Methods of Physics. 3 points.

Prerequisites: PHYS UN3003 and PHYS UN3007 and differential and integral calculus; linear algebra; or the instructor's permission.
This course will present a wide variety of mathematical ideas and techniques used in the study of physical systems. Topics will include: ordinary and partial differential equations; generalized functions; integral transforms; Green's functions; nonlinear equations, chaos, and solitons; Hilbert space and linear operators; Feynman path integrals; Riemannian manifolds; tensor analysis; probability and statistics. There will also be a discussion of applications to classical mechanics, fluid dynamics, electromagnetism, plasma physics, quantum mechanics, and general relativity.

Fall 2021: PHYS GU4019

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 4019	001/11948	T Th 2:40pm - 3:55pm Room TBA	Yury Levin	3	19/50

PHYS GU4021 Quantum Mechanics I. 3 points.

Prerequisites: PHYS UN3003 and PHYS UN3007
Formulation of quantum mechanics in terms of state vectors and linear operators. Three dimensional spherically symmetric potentials. The theory of angular momentum and spin. Identical particles and the exclusion principle. Methods of approximation. Multi-electron atoms.

Fall 2021: PHYS GU4021

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 4021	001/11949	T Th 11:40am - 12:55pm Room TBA	William Zajc	3	41/100

PHYS GU4022 Quantum Mechanics II. 3 points.

Prerequisites: PHYS GU4021. Formulation of quantum mechanics in terms of state vectors and linear operators, three-dimensional spherically symmetric potentials, the theory of angular momentum and spin, time-independent and time-dependent perturbation theory, scattering theory, and identical particles. Selected phenomena from atomic physics, nuclear physics, and elementary particle physics are described and then interpreted using quantum mechanical models.

Spring 2021: PHYS GU4022

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 4022	001/10237	T Th 11:40am - 12:55pm 329 Pupin Laboratories	William Zajc	3	28/60

PHYS GU4023 Thermal and Statistical Physics. 3 points.

Prerequisites: PHYS GU4021 or the equivalent.
Thermodynamics, kinetic theory, and methods of statistical mechanics; energy and entropy; Boltzmann, Fermi, and Bose distributions; ideal and real gases; blackbody radiation; chemical equilibrium; phase transitions; ferromagnetism.

Fall 2021: PHYS GU4023

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
PHYS 4023	001/11950	T Th 1:10pm - 2:25pm Room TBA	Andrew Millis	3	23/100

PHYS GU4024 Applied Quantum Mechanics. 3 points.

Prerequisites: (PHYS GU4021 and PHYS GU4022)
In this course, we will learn how the concepts of quantum mechanics are applied to real physical systems, and how they enable novel applications in quantum optics and quantum information. We will start with microscopic, elementary quantum systems – electrons, atoms, and ions - and understand how light interacts with atoms. Equipped with these foundations, we will discuss fundamental quantum applications, such as atomic clocks, laser cooling and ultracold quantum gases - a synthetic form of matter, cooled down to just a sliver above absolute zero temperature. This leads us to manybody quantum systems. We will introduce the quantum physics of insulating and metallic behavior, superfluidity and quantum magnetism – and demonstrate how the corresponding concepts apply both to real condensed matter systems and ultracold quantum gases. The course will conclude with a discussion of the basics of quantum information science - bringing us to the forefront of today's quantum applications.

PHYS GU4040 Introduction to General Relativity. 3 points.

Prerequisites: PHYS UN3003 and PHYS UN3007 or the equivalent.
Tensor algebra, tensor analysis, introduction to Riemann geometry. Motion of particles, fluid, and fields in curved spacetime. Einstein equation. Schwarzschild solution; test-particle orbits and light bending. Introduction to black holes, gravitational waves, and cosmological models.

PHYS GU4050 Introduction to Particle Physics. 3 points.

Prerequisites: PHYS UN2601 or PHYS UN2802 or the equivalent.
This course covers the Standard Model of Particle Physics, including its conception, successes, and limitations, with the goal of introducing upper-level physics majors to the foundations and current status of particle physics as a field of research. Specific topics to be covered include: historical introduction and review of the Standard Model; particle interactions and particle dynamics; relativistic kinematics; Feynman calculus, quantum electrodynamics, quantum chromodynamics, and weak interactions; electroweak unification and the Higgs mechanism; neutrino oscillations; and beyond-standard model physics and evidence. Along the way, students will research special topics and familiarize themselves with particle physics research.