

# Department of Physics and Astronomy

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## Mission Statement

The Department of Physics and Astronomy is committed to excellence in undergraduate instruction for students representing all segments of the university. For physics majors the department offers a program of study based on courses in the broad areas of physics and astronomy and student participation in research. The multi-track degree program of study allows students flexibility to select courses that support their career plans. The department offers courses that are required by other disciplines and shares in the university-wide General Education program. The Department of Physics and Astronomy is committed to providing a supportive environment within which students can achieve their full potential and faculty and staff can make their maximum contribution while enjoying the rewards of professional development.

## Goals

To help students:

- appreciate the role of science in society and the historical development of physics in the ongoing quest to discover the structure of the universe.
- gain an understanding of the basic principles and the experimental basis of the various fields of physics and the logical relationships of the various fields.
- become capable problem solvers using techniques that require mathematical skills, conceptual and mathematical models, order-of-magnitude estimates and an understanding of limiting cases.
- develop competence in designing, constructing and using laboratory instruments and to draw valid conclusions from experimental data.
- develop competence in using computers for computation, data acquisition, numerical control, device development and information acquisition and processing.
- improve written and oral technical communication skills.

## Co-Curricular Activities and Organizations

- Society of Physics Students

## Degree and Major Requirements

### Bachelor of Arts in Physics

### Degree Requirements

| Required Courses  | Credit Hours |
|---|--------------|
| General Education <sup>1</sup>                                      | 41           |
| Foreign Language classes (intermediate level required) <sup>2</sup> | 0-14         |
| Philosophy course (in addition to General Education courses)        | 3            |
| University electives  | 23-37        |
| Major core requirements (listed below) <sup>3</sup>                 | 40           |
| Major concentration requirements (listed below) <sup>3</sup>        | 25-38        |
|   | 120          |

<sup>1</sup> The General Education program contains a set of requirements each student must fulfill. The number of credit hours necessary to fulfill these requirements may vary.

<sup>2</sup> The foreign language requirement may be satisfied by successful completion of the second semester of the intermediate level (typically 232) of the student's chosen language or by placing out of that language through the Department of Foreign Languages, Literatures and Cultures' placement test.

<sup>3</sup> Some of the courses required for the major complete Cluster Three of General Education. *PHIL 101* is part of Cluster Two, and the additional philosophy requirement is covered is the physics and philosophy concentration is chosen.

### Program Concentrations

Each student, in consultation with his/her faculty adviser, will choose one of the following program concentrations:

- Physics and Philosophy
- Individual Option

### Major Core Requirements

| Courses   | Credit Hours |
|---|--------------|
| PHYS 240, 250 and 260. University Physics I-III               | 10           |
| PHYS 247. Data Acquisition and Analysis Techniques in Physics | 2            |
| PHYS 270. Modern Physics                                      | 4            |
| MATH 235, 236 and 237. Calculus I-III                         | 12           |
| MATH 238. Linear Algebra with Differential Equations          | 4            |
| CHEM 131 + 131L. General Chemistry with lab                   | 4            |
| Choose one:   | 4            |
| BIO 114. Organisms  |              |
| GEOL 110. Physical Geology                                    |              |

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In addition, the student must complete one of the following concentrations.

### Physics and Philosophy

| Courses  | Credits |
|--|---------|
| PHYS 347. Advanced Physics Laboratory                    | 3       |
| PHYS 340. Mechanics                                      | 3       |
| PHYS 350. Electricity and Magnetism                      | 3       |
| PHYS 380. Thermodynamics and Statistical Mechanics       | 3       |
| PHYS 460. Quantum Mechanics                              | 3       |
| PHYS 491-492. Physics Assessment and Seminar             | 1       |
| Choose one:  | 3-4     |
| MATH 248. Computers and Numerical Algorithms (4 credits) |         |
| PHYS 326. Biophysics (3 credits)                         |         |
| ASTR courses numbered above 301 (3 credits)              |         |
| <b>GP</b> PHIL 101. Introduction to Philosophy           | 3       |
| Choose two:  | 6       |
| PHIL 340. Ancient Greek Philosophy                       |         |
| PHIL 341. Modern Philosophy                              |         |
| PHIL 342. Medieval Philosophy                            |         |
| PHIL 375. Nineteenth Century Philosophy and Theology     |         |
| Choose three:  | 9       |
| PHIL 310. Symbolic Logic                                 |         |
| PHIL 311. Metaphysics                                    |         |
| PHIL 312. Causal and Explanatory Thinking                |         |
| PHIL 320. Inductive Logic                                |         |
| PHIL 392. Philosophy of Mind                             |         |
| PHIL 395. Philosophy and Scientific Inquiry              |         |

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### Individual Option

The individual option is a course of study chosen specifically to match the interest and career plans of the student. This option will allow custom designed interdisciplinary majors such as the history of physics and physics and the fine arts.

A student electing the individual option must complete the major core requirements of the B.A. in physics and will select a program consisting of a coherent collection of a minimum of 25 additional credits of physics courses numbered above 260, astronomy courses numbered above 301, and courses in related fields. This individualized program must be selected in consultation with a faculty adviser in the department and must be approved by that adviser, the department head and one other faculty member in the department.

The individualized program, as approved by the department and accepted by the student, becomes the major requirements for the student.

Students are expected to review progress toward completion of the selected program of study with their faculty adviser.

## Bachelor of Science in Physics

### Degree Requirements

| Required Courses   | Credit Hours |
|--|--------------|
| General Education <sup>1</sup>                                     | 41           |
| Quantitative requirement (in addition to General Education)        | 3            |
| Scientific Literacy requirement (in addition to General Education) | 3-4          |
| University electives   | 2-8          |
| Major core requirements (listed below)                             | 40           |
| Major program concentration requirements                           | 25-31        |
|  | <hr/> 120    |

<sup>1</sup> The General Education program contains a set of requirements each student must fulfill. The number of credit hours necessary to fulfill these requirements may vary.

## Major Core Requirements

|   | Credit Hours |
|---|--------------|
| Choose one of the following:                                  | 6            |
| PHYS 140-150. College Physics I-II                            |              |
| PHYS 240-250. University Physics I-II                         |              |
| PHYS 247. Data Acquisition and Analysis Techniques in Physics | 2            |
| PHYS 260. University Physics III                              | 4            |
| PHYS 270. Modern Physics                                      | 4            |
| Cognate Disciplines   |              |
| CHEM 131-132. General Chemistry I-II                          | 6            |
| CHEM 131L-132L. General Chemistry Lab I-II                    | 2            |
| MATH 235-237. Calculus I-III                                  | 12           |
| MATH 248. Computer Methods in Engineering and Science         | 4            |
|   | <hr/> 40     |

## Program Concentrations

Each student, in consultation with their faculty adviser, will choose one of the following program concentrations:

- Applied Physics
- Physics/Engineering Combined Program
- Fundamental Studies
- Individual Option
- Multidisciplinary

### Applied Physics Concentration

The applied physics concentration is designed to prepare students for careers in a wide variety of scientific areas including laboratory and industrial settings. It is separated into three tracks: computational physics, materials physics, and electronics and instrumentation.

All students in the applied physics concentration must complete the following courses:

| Required Courses<br>(in addition to core requirements)     | Credit Hours |
|--|--------------|
| PHYS 360. Analog Electronics                               | 4            |
| PHYS 347. Advanced Physics Laboratory                      | 3            |
| PHYS 391-392. Seminar                                      | 1            |
| PHYS 491-492. Assessment and Seminar                       | 1            |
| PHYS/ASTR 498R. Applied Physics Research                   | 2            |
| Additional physics courses approved by the physics adviser | 3            |

In addition to the required courses, students must complete one of the following tracks:

| Electronics and Instrumentation                            | Credit Hours |
|--|--------------|
| PHYS 350. Electricity and Magnetism                        | 3            |
| PHYS 371. Digital Electronics                              | 2            |
| PHYS/CS 372. Microcontrollers and Applications             | 2            |
| PHYS 380. Thermodynamics and Statistical Mechanics         | 3            |
| Additional physics courses approved by the physics adviser | 2-3          |

| Materials Physics                                   | Credit Hours |
|---|--------------|
| PHYS 340. Mechanics                                 | 3            |
| PHYS 350. Electricity and Magnetism                 | 3            |
| PHYS/MATS 275. An Introduction to Materials Science | 3            |
| PHYS/MATS 381. Material Characterization with Lab   | 3            |

| Computational Physics                              | Credit Hours |
|--|--------------|
| PHYS 340. Mechanics                                | 3            |
| PHYS 380. Thermodynamics and Statistical Mechanics | 3            |
| Choose one of the following pairs of courses:      | 6            |

- PHYS 265. Introduction to Fluid Mechanics
- MATH 365. Computational Fluid Mechanics or
- PHYS 266. Introduction to Solid Mechanics
- MATH 366. Computational Solid Mechanics

Students in this track must minor in mathematics.

## Physics and Engineering Combined Program Concentration

This dual degree program makes it possible for the student to earn a B.S. degree in physics from JMU and a Master of Engineering degree from the University of Virginia. The engineering areas available under this program include biomedical, environmental, transportation, materials science, systems engineering and engineering physics.

During the first three years at JMU, the student must complete 96 credit hours including all JMU general education requirements, the physics core requirements, differential equations and at least 12 additional credit hours in physics courses designated by the JMU Department of Physics and Astronomy with at least a "B+" average. In general these 12 additional hours will be chosen from those recommended for the applied physics track, but substitutions may be approved by the department head. During the fourth year of study (when the student will be in residence at the University of Virginia), the student will take further courses approved by the JMU Department of Physics and Astronomy for credit toward the Bachelor of Science degree in physics. A total of 37 credit hours of physics or other physics-related courses taken at either school will be required for the JMU Bachelor of Science degree in physics. For further information, consult the head of the Department of Physics and Astronomy.

## Fundamental Studies Concentration

The fundamental studies concentration is designed to prepare students for immediate post-baccalaureate employment or for entrance to advanced study in physics or related areas.

| Required Courses<br>(in addition to core requirements)                     | Credit<br>Hours |
|--|-----------------|
| MATH 238. Linear Algebra with Differential Equations                       | 4               |
| PHYS 340. Mechanics  | 3               |
| PHYS 350. Electricity and Magnetism  | 3               |
| PHYS 347. Advanced Physics Laboratory                                      | 3               |
| PHYS 360. Analog Electronics   | 4               |
| PHYS 380. Thermodynamics and Statistical Mechanics                         | 3               |
| PHYS 391-392. Seminar  | 1               |
| PHYS 460. Quantum Mechanics  | 3               |
| PHYS 491-492. Assessment and Seminar                                       | 1               |
| Choose one of the following:   | 2-6             |
| PHYS/ASTR 398. Problems in Physics or Astronomy (2 credits)                |                 |
| PHYS/ASTR 498R. Undergraduate Research in Physics or Astronomy (2 credits) |                 |
| ISCI 450. Interscience Research (2 credits)                                |                 |
| PHYS 494. Internship in Physics (2 credits)                                |                 |
| PHYS 499. Honors (6 credits)   |                 |

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## Individual Option Concentration

The individual option is a course of studies chosen specifically to match the interest and career plans of the student. This option will allow custom designed interdisciplinary majors such as geophysics and chemical physics, as well as majors designed for students whose educational and career goals are not met by the existing concentrations in the major.

A student electing the individual option must complete the core requirements for the B.S. in physics and will select a program consisting of a coherent collection of a minimum of 25 additional credits of physics courses numbered above 260, astronomy courses numbered above 301 and courses in related fields.

This individualized program must be selected in consultation with a faculty adviser in the department, and must be approved by that adviser, the department head and one other faculty member in the department.

The individualized program, as approved by the department and accepted by the student, becomes the major requirements for that student.

Students are expected to review progress toward completion of the selected program of study with their faculty adviser.

## Computational Sciences Track

Computational sciences is a track within the applied physics concentration. The Department of Mathematics and Statistics and the Department of Physics and Astronomy offer a coordinated sequence of courses that prepares students for careers in the rapidly expanding field of computer modeling of complex systems. This program is structured so that students can earn a major in one department and a minor in the other.

Students need not decide on a major field until their junior year. The computational sciences track will prepare students to design and use computer models in any of those areas in which applied mathematics is used to understand complex systems (meteorology, astronomy, geology/geophysics, oceanography, physics, etc.). The preparation is appropriate for both those students who plan to enter the work force after graduation and those who plan to enter graduate school in applied mathematics, physics or one of the other fields mentioned above.

Students in this track should complete the following courses during the first two years of the program:

|   |
|---|
| MATH 235-237. Calculus I-III  |
| MATH 238. Linear Algebra with Differential Equations  |
| MATH 248. Computer Methods in Engineering and Science   |
| PHYS 140L-150L. General Physics Laboratory I-II<br>or PHYS 247. Data Acquisition and Analysis Techniques in Physics |
| PHYS 240-260. University Physics I-III  |
| PHYS 265. Introduction to Fluid Mechanics<br>or PHYS 266. Introduction to Solid Mechanics                           |

During their junior and senior years, students will normally complete the necessary course work for their major and minor. Mathematics majors will take PHYS 340, Mechanics and MATH/PHYS 365, Introduction to Computational Fluid Mechanics, or MATH/PHYS 366, Introduction to Computational Solid Mechanics counted as a physics course to complete their physics minor. Physics majors will take PHYS/MATH 365 or PHYS/MATH 366, counted as a mathematics course, and either MATH 337, Applied Calculus or MATH 387, Fourier Analysis and Partial Differential Equations to complete their mathematics minor. Seniors in either major must complete at least one topics or independent-study/research course that involves computer modeling.

## Multidisciplinary Concentration

The multidisciplinary concentration is designed to provide a solid foundation in physics for those students whose interests extend beyond traditional physics fields. The four tracks of business, technical and scientific communication, biophysics and secondary education open doors to the pursuit of graduate degrees in law, the medical sciences, business and education, and other career paths that require a technical background.

Additionally, the concentrations in business and technical and scientific communication concentrations are excellent preparation for jobs in industry.

The following are also required for all tracks in the multidisciplinary concentration.

| Courses  | Credit Hours |
|--|--------------|
| MATH 238. Linear Algebra with Differential Equations                       | 4            |
| BIO 114. Organisms   | 4            |
| PHYS/CHEM/MATS 275. An Introduction to Materials Science                   | 3            |
| PHYS 340. Mechanics  | 3            |
| PHYS 350. Electricity and Magnetism  | 3            |
| PHYS 380. Thermodynamics and Statistical Mechanics                         | 3            |
| PHYS 391-392. Seminar  | 1            |
| PHYS 491-492. Physics Assessment and Seminar                               | 2            |
| Two credits from the following   | 2            |
| PHYS/ASTR 398. Independent Study in Physics and Astronomy (2 credits)      |              |
| PHYS/ASTR 498R. Undergraduate Research in Physics or Astronomy (2 credits) |              |
| ISCI 450. Interscience Research (2 credits)                                |              |
| PHYS 494. Internship in Physics (2 credits)                                |              |
| PHYS 499. Honors (6 credits)   |              |
|  | 25           |

The student must choose one of the following tracks.

| Business Track                                  | Credit Hours |
|---|--------------|
| COB 204. Computer Information Systems           | 3            |
| COB 218. Legal Environment of Business          | 3            |
| COB 241. Financial Accounting                   | 3            |
| ECON 201. Principles of Economics (Micro)       | 3            |
| FIN 345. Managerial Finance                     | 3            |
| MGT 305. Management and Organizational Behavior | 3            |
| MKTG 380. Principles of Marketing               | 3            |
|   | 21           |

#### Technical and Scientific

| Communication Track  | Credit Hours |
|--|--------------|
| Choose six credits:  | 6            |
| Physics course numbered above 300  |              |
| ASTR 480. Astrophysics   |              |
| GWRTC 103. Critical Reading and Writing                                      | 3            |
| WRTC 210. Introduction to Technical and Scientific Communication             | 3            |
| WRTC 230. Research in Technical and Scientific Communication                 | 3            |
| WRTC 240. Technical and Scientific Editing                                   | 3            |
| Choose six credits:  | 6            |
| WRTC 250. Ethical and Legal Issues in Technical and Scientific Communication |              |
| WRTC 330. Intercultural Technical and Scientific Communication               |              |
| WRTC 350. Science and Technology in Literature                               |              |
| WRTC 360. Instructional Design and Training                                  |              |
| Other upper-level courses with permission                                    |              |
|  | 24           |

| Biophysics Track                        | Credit Hours |
|---|--------------|
| PHYS 326. Biophysics                    | 3            |
| CHEM 341-342. Organic Chemistry         | 6            |
| CHEM 346L. Organic Chemistry Laboratory | 2            |
| CHEM/BIO 361. Biochemistry I            | 3            |
| BIO 214. Cell and Molecular Biology     | 4            |
| BIO 370. Animal Physiology              | 4            |
| BIO 490. Biomechanics                   | 4            |
|   | 26           |

#### Secondary Education Track

Students interested in becoming teachers must meet specific curriculum requirements in their major as part of the undergraduate academic degree.

In addition to the general education and academic major requirements, physics majors desiring secondary teacher licensure must be admitted to teacher education, complete the pre-professional program in secondary education at the undergraduate level and complete the graduate level Master of Arts in Teaching degree.

It is critical that students seeking licensure consult regularly with both their education adviser and their major adviser to support their progression through the programs. For a full description of the program in secondary teaching, refer to the Department of Middle, Secondary and Mathematics Education, in addition to the College of Education section of the catalog.

The required courses for the undergraduate degree are:

| Course   | Credit Hours |
|--|--------------|
| OPSYC 160. Life Span Human Development   | 3            |
| EDUC 360. Instructional Technology   | 3            |
| Students must be fully admitted into pre-professional teacher education prior to enrolling in these courses: |              |
| EDUC 310. Teaching in a Diverse Society  | 3            |
| MSSE 370. General Instruction Methods for Grades 6-12  | 3            |
| MSSE 371. Clinical Experience in Adolescent Education  | 1            |
| MSSE 470S. Natural Sciences Teaching Methods, Grades 6-8   | 3            |
| MSSE 471S. Field Experience in Middle School Natural Science   | 3            |
| READ 440. Literacy-Based Learning in Secondary Education   | 3            |

## Recommended Schedule for Majors

| First Year  | Credit Hours |
|---|--------------|
| CHEM 131-132. General Chemistry I-II                          | 6            |
| CHEM 131L-132L. General Chemistry Laboratory                  | 2            |
| Skills for the 21st Century (General Education, Cluster One)  | 9-12         |
| MATH 235-236. Calculus I-II                                   | 8            |
| PHYS 247. Data Acquisition and Analysis Techniques in Physics | 2            |
| Choose one of the following:                                  | 6            |
| PHYS 240-250. University Physics I-II                         |              |
| PHYS 140-150. College Physics I-II                            |              |
|   | 33-36        |

| Second Year  | Credit Hours |
|--|--------------|
| MATH/CS 248. Computer Methods in Engineering and Science | 4            |
| MATH 237. Calculus III                                   | 4            |
| MATH 238. Linear Algebra with Differential Equations     | 4            |
| PHYS 260. University Physics III                         | 4            |
| PHYS 270. Modern Physics                                 | 4            |
| General Education courses                                | 11           |
|  | 31           |

#### Third and Fourth Years

During their junior and senior years, students will select courses to complete the specific program track which they are following. These course selections will be made with the assistance of a faculty adviser.

## Minor Requirements

### Astronomy Minor

The minimum requirement for a minor in astronomy is 21 credit hours selected as follows:

|   | <b>Credit Hours</b> |
|---|---------------------|
| Choose one of the following:  | 6                   |
| PHYS 240-250. University Physics I-II   |                     |
| PHYS 140-150. College Physics I-II  |                     |
| Choose one of the following:  | 2                   |
| PHYS 140L-150L. General Physics Laboratory I-II   |                     |
| PHYS 247. Data Acquisition and Analysis Techniques in Physics   |                     |
| ASTR 220-221. General Astronomy I-II  | 7                   |
| ASTR 320. Astronomical Techniques   | 3                   |
| One course selected from the following:   | 3                   |
| PHYS 480. Astrophysics  |                     |
| GEOL 272. Planetary Geology   |                     |
| HON 300Z. Life Beyond Earth   |                     |
| PHYS 297, PHYS 397 or PHYS 497. Topics in Physics (appropriate topics could include relativity, cosmology, cosmic rays) |                     |
| ASTR 297, ASTR 397, ASTR 497. Topics in Astronomy   |                     |
| <hr style="width: 100px; margin-left: auto;"/>  | 21                  |

### Physics Minor

The minimum requirement for a minor in physics is 22 credit hours selected as follows:

|   | <b>Credit Hours</b> |
|---|---------------------|
| Choose one of the following:                                  | 6                   |
| PHYS 240-250. University Physics I-II                         |                     |
| PHYS 140-150. College Physics I-II                            |                     |
| Choose one of the following:                                  | 2                   |
| PHYS 140L-150L. General Physics Laboratory I-II               |                     |
| PHYS 247. Data Acquisition and Analysis Techniques in Physics |                     |
| PHYS 260. University Physics III                              | 4                   |
| Ten credits selected from the following:                      | 10                  |
| Physics courses numbered above 260                            |                     |
| ASTR 320. Astronomical Techniques                             |                     |
| ASTR 480. Astrophysics  |                     |
| <hr style="width: 100px; margin-left: auto;"/>                | 22                  |