

# PHYSICS, BS

**Banner Code:** SC-BS-PHYS

## Undergraduate Physics Advisor

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Fairfax Campus

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The Physics, BS program prepares students for graduate school and careers in education, business, or industry.

## Teacher Licensure

Students who wish to become teachers and plan to seek teacher licensure should consider the following options:

- Curriculum and Instruction Undergraduate Certificate
- Physics, BS/Curriculum and Instruction, Accelerated MEd (Secondary Education Physics concentration)

Interested students should attend an information session early in their undergraduate career. For more information, visit the Graduate School of Education's website (<http://gse.gmu.edu>).

## Admissions & Policies

### Admissions

University-wide admissions policies can be found in the Undergraduate Admissions Policies section of this catalog.

To apply for this program, please complete the George Mason University Admissions Application (<https://www2.gmu.edu/admissions-aid/apply-now>).

### Policies

Students must fulfill all Requirements for Bachelor's Degrees including the Mason Core.

The intensive writing requirement is fulfilled by taking PHYS 407 Senior Laboratory in Modern Physics (Mason Core) or ASTR 402 RS: Methods of Observational Astronomy (Mason Core), which are also capstone courses for the major.

For policies governing all undergraduate programs, see AP.5 Undergraduate Policies.

### Double Majors

Students considering a double major with physics should discuss this option with the respective undergraduate coordinators.

Note that at least 18 credits used to fulfill the Physics, BS cannot be used to fulfill another major or minor. Some course substitutions are allowed for double majors, but these should be discussed with a physics advisor in advance.

## Alternative Introductory Sequence

Normally, students who intend to major in physics should take the physics introductory sequence:

| Code     | Title   | Credits |
|----------|---|---------|
| PHYS 160 | University Physics I (Mason Core)             | 3       |
| PHYS 161 | University Physics I Laboratory (Mason Core)  | 1       |
| PHYS 260 | University Physics II (Mason Core)            | 3       |
| PHYS 261 | University Physics II Laboratory (Mason Core) | 1       |

Students who decide to major in physics after completing PHYS 243 College Physics I (Mason Core), PHYS 244 College Physics Lab (Mason Core), PHYS 245 College Physics II (Mason Core) and PHYS 246 College Physics Lab (Mason Core) are welcome, but are required to obtain written permission from the Department of Physics and Astronomy before a change of major can be approved.

## Requirements

### Degree Requirements

Total credits: minimum 120

Students should refer to the Admissions & Policies tab for specific policies related to this program.

Students must complete a total of 75 credits in the major (69 credits if completing a second major), including at least 11 credits in mathematics, with a minimum GPA of 2.00.

Students must complete the coursework described below and either select a concentration or select the "BS without Concentration" option:

### Physics Core Courses

| Code          | Title   | Credits |
|---------------|---|---------|
| PHYS 160      | University Physics I (Mason Core)                           | 3       |
| PHYS 161      | University Physics I Laboratory (Mason Core)                | 1       |
| PHYS 251      | Introduction to Computer Techniques in Physics (Mason Core) | 3       |
| PHYS 260      | University Physics II (Mason Core)                          | 3       |
| PHYS 261      | University Physics II Laboratory (Mason Core)               | 1       |
| PHYS 301      | Analytical Methods of Physics                               | 3       |
| PHYS 303      | Classical Mechanics   | 3       |
| PHYS 305      | Electromagnetic Theory <sup>1</sup>                         | 3       |
| PHYS 307      | Thermal Physics   | 3       |
| PHYS 308      | Modern Physics with Applications                            | 3       |
| PHYS 402      | Introduction to Quantum Mechanics and Atomic Physics        | 3       |
| PHYS 416      | Special Topics in Undergraduate Physics                     | 1       |
| Total Credits |   | 30      |

<sup>1</sup> Students double majoring in engineering and physics may substitute ECE 305 Electromagnetic Theory for PHYS 305 Electromagnetic Theory.

## Mathematics

| Code          | Title   | Credits |
|---------------|---|---------|
| MATH 113      | Analytic Geometry and Calculus I (Mason Core) | 4       |
| MATH 114      | Analytic Geometry and Calculus II             | 4       |
| MATH 213      | Analytic Geometry and Calculus III            | 3       |
| Total Credits |   | 11      |

## BS without Concentration

| Code                                     | Title | Credits |
|--|-------|---------|
| <b>Mathematics/Computational Physics</b> |       | 6       |

Select 6 credits from the following:

|          |                                   |
|----------|-----------------------------------|
| PHYS 410 | Computational Physics Capstone    |
| MATH 203 | Linear Algebra                    |
| MATH 214 | Elementary Differential Equations |

|                                |  |   |
|--------------------------------|--|---|
| <b>Intermediate Laboratory</b> |  | 6 |
|--------------------------------|--|---|

|          |                  |
|----------|------------------|
| PHYS 311 | Instrumentation  |
| PHYS 312 | Waves and Optics |

|   |  |   |
|---|--|---|
| <b>Research, Internship, or Independent Study</b> |  | 3 |
|---|--|---|

Select 3 credits from the following:

|          |                             |
|----------|-----------------------------|
| PHYS 326 | Problems in Physics II      |
| PHYS 405 | Honors Thesis in Physics I  |
| PHYS 406 | Honors Thesis in Physics II |
| PHYS 408 | Senior Research             |
| PHYS 409 | Physics Internship          |

|                 |  |   |
|-----------------|--|---|
| <b>Capstone</b> |  | 4 |
|-----------------|--|---|

|          |   |
|----------|---|
| PHYS 407 | Senior Laboratory in Modern Physics (Mason Core) <sup>1</sup> |
|----------|---|

|                       |  |      |
|-----------------------|--|------|
| <b>Physics Theory</b> |  | 9-15 |
|-----------------------|--|------|

All students complete the following 9 credits:

|          |   |
|----------|---|
| PHYS 306 | Wave Motion and Electromagnetic Radiation |
| PHYS 403 | Quantum Mechanics II                      |
| PHYS 428 | Relativity                                |

Only students who are not completing a second major must select 6 additional credits from the following:

|          |                                       |
|----------|---------------------------------------|
| ASTR 210 | Introduction to Astrophysics          |
| ASTR 328 | Stars                                 |
| ASTR 403 | Planetary Science                     |
| ASTR 404 | Galaxies and Cosmology                |
| PHYS 370 | Molecular Biophysics                  |
| PHYS 412 | Solid State Physics and Applications  |
| PHYS 440 | Nuclear and Particle Physics          |
| PHYS 465 | Planetary Atmospheres and Ionospheres |
| PHYS 475 | Atmospheric Physics                   |

|               |  |       |
|---------------|--|-------|
| Total Credits |  | 28-34 |
|---------------|--|-------|

<sup>1</sup> Fulfills the writing intensive requirement.

## Applied and Engineering Physics Concentration (PHAE)

| Code                                     | Title | Credits |
|--|-------|---------|
| <b>Mathematics/Computational Physics</b> |       | 3       |

|          |                                |
|----------|--------------------------------|
| PHYS 410 | Computational Physics Capstone |
|----------|--------------------------------|

|                                |  |   |
|--------------------------------|--|---|
| <b>Intermediate Laboratory</b> |  | 6 |
|--------------------------------|--|---|

|          |                  |
|----------|------------------|
| PHYS 311 | Instrumentation  |
| PHYS 312 | Waves and Optics |

|                       |  |   |
|-----------------------|--|---|
| <b>Physics Theory</b> |  | 9 |
|-----------------------|--|---|

|          |   |
|----------|---|
| PHYS 306 | Wave Motion and Electromagnetic Radiation |
|----------|---|

Select 6 credits from the following:

|          |                                      |
|----------|--------------------------------------|
| PHYS 370 | Molecular Biophysics                 |
| PHYS 403 | Quantum Mechanics II                 |
| PHYS 412 | Solid State Physics and Applications |

|                 |  |   |
|-----------------|--|---|
| <b>Capstone</b> |  | 4 |
|-----------------|--|---|

|          |   |
|----------|---|
| PHYS 407 | Senior Laboratory in Modern Physics (Mason Core) <sup>1</sup> |
|----------|---|

|                       |  |      |
|-----------------------|--|------|
| <b>Practical Work</b> |  | 6-12 |
|-----------------------|--|------|

Students who are not completing a second major should select 12 credits from the following. Students who are completing a second major should select 6 credits:

|          |                                    |
|----------|------------------------------------|
| PHYS 405 | Honors Thesis in Physics I         |
| PHYS 406 | Honors Thesis in Physics II        |
| PHYS 408 | Senior Research                    |
| PHYS 409 | Physics Internship                 |
| BENG 320 | Bioengineering Signals and Systems |

Or other approved 300 or 400-level Volgenau School of Engineering courses

|               |  |       |
|---------------|--|-------|
| Total Credits |  | 28-34 |
|---------------|--|-------|

<sup>1</sup> Fulfills the writing intensive requirement.

## Astrophysics Concentration (PHAP)

| Code                                     | Title | Credits |
|--|-------|---------|
| <b>Mathematics/Computational Physics</b> |       | 3       |

Select 3 credits from the following:

|          |                                   |
|----------|-----------------------------------|
| ASTR 401 | Computer Simulation in Astronomy  |
| PHYS 410 | Computational Physics Capstone    |
| MATH 214 | Elementary Differential Equations |

|                                |  |   |
|--------------------------------|--|---|
| <b>Intermediate Laboratory</b> |  | 6 |
|--------------------------------|--|---|

|          |                  |
|----------|------------------|
| PHYS 311 | Instrumentation  |
| PHYS 312 | Waves and Optics |

|   |  |   |
|---|--|---|
| <b>Research, Internship, or Independent Study</b> |  | 3 |
|---|--|---|

Select 3 credits from the following:

|          |                               |
|----------|-------------------------------|
| ASTR 405 | Honors Thesis in Astronomy I  |
| ASTR 406 | Honors Thesis in Astronomy II |
| ASTR 408 | Senior Research               |
| ASTR 409 | Astronomy Internship          |
| PHYS 326 | Problems in Physics II        |
| PHYS 405 | Honors Thesis in Physics I    |
| PHYS 406 | Honors Thesis in Physics II   |
| PHYS 408 | Senior Research               |
| PHYS 409 | Physics Internship            |

**Capstone** 4

Select 4 credits from the following:

|          |   |
|----------|---|
| ASTR 402 | RS: Methods of Observational Astronomy (Mason Core)           |
| PHYS 407 | Senior Laboratory in Modern Physics (Mason Core) <sup>1</sup> |

**Physics and Astronomy Theory** 12-18**Students who are not completing a second major must complete the following:**

|          |   |
|----------|---|
| ASTR 210 | Introduction to Astrophysics              |
| ASTR 328 | Stars                                     |
| ASTR 403 | Planetary Science                         |
| ASTR 404 | Galaxies and Cosmology                    |
| PHYS 306 | Wave Motion and Electromagnetic Radiation |
| PHYS 428 | Relativity                                |

**Students who are completing a second major must complete the following:**

|          |                              |
|----------|------------------------------|
| ASTR 210 | Introduction to Astrophysics |
| ASTR 328 | Stars                        |

Additionally, select 3 credits from the following:

|          |   |
|----------|---|
| PHYS 306 | Wave Motion and Electromagnetic Radiation |
| PHYS 428 | Relativity                                |

Lastly, select 3 credits from the following:

|          |                        |
|----------|------------------------|
| ASTR 403 | Planetary Science      |
| ASTR 404 | Galaxies and Cosmology |

Total Credits 28-34

<sup>1</sup> Fulfills the writing intensive requirement.**Computational Physics Concentration (PHCP)****Code Title Credits**  
**Mathematics/Computational Physics** 15

|          |                                   |
|----------|-----------------------------------|
| PHYS 410 | Computational Physics Capstone    |
| MATH 203 | Linear Algebra                    |
| MATH 214 | Elementary Differential Equations |

Additionally, select 6 credits from the following:

|          |                                  |
|----------|----------------------------------|
| ASTR 401 | Computer Simulation in Astronomy |
| CDS 302  | Scientific Data and Databases    |
| CDS 303  | Scientific Data Mining           |
| MATH 446 | Numerical Analysis I             |
| MATH 447 | Numerical Analysis II            |

**Intermediate Laboratory** 3

|          |                 |
|----------|-----------------|
| PHYS 311 | Instrumentation |
|----------|-----------------|

**Research, Internship, or Independent Study** 3

Select 3 credits from the following:

|          |                             |
|----------|-----------------------------|
| PHYS 326 | Problems in Physics II      |
| PHYS 405 | Honors Thesis in Physics I  |
| PHYS 406 | Honors Thesis in Physics II |
| PHYS 408 | Senior Research             |
| PHYS 409 | Physics Internship          |

**Capstone** 4

Select 4 credits from the following:

|          |  |
|----------|--|
| ASTR 402 | RS: Methods of Observational Astronomy (Mason Core) <sup>1</sup> |
| PHYS 407 | Senior Laboratory in Modern Physics (Mason Core) <sup>1</sup>    |

**Physics and Astronomy Theory** 3-9

Students who are not completing a second major must select 9 credits of the following. Students who are completing a second major must select 3 credits from the following:

|          |   |
|----------|---|
| ASTR 210 | Introduction to Astrophysics              |
| ASTR 328 | Stars                                     |
| ASTR 403 | Planetary Science                         |
| PHYS 306 | Wave Motion and Electromagnetic Radiation |
| PHYS 412 | Solid State Physics and Applications      |

Total Credits 28-34

<sup>1</sup> Fulfills the writing intensive requirement.**Mason Core and Elective Credits**

In order to meet a minimum of 120 credits, this degree requires 45 (or 51 if completing a second major) additional credits, which may be applied toward any remaining Mason Core requirements (outlined below), Requirements for Bachelor's Degrees, and elective courses. Students are strongly encouraged to consult with their advisors to ensure that they fulfill all requirements.

**Mason Core**

Some Mason Core requirements may already be fulfilled by the major requirements listed above. Students are strongly encouraged to consult their advisors to ensure they fulfill all remaining Mason Core requirements.

| Code                            | Title                                | Credits |
|---------------------------------|--------------------------------------|---------|
| <b>Foundation Requirements</b>  |                                      |         |
|                                 | Written Communication (ENGH 101)     | 3       |
|                                 | Oral Communication                   | 3       |
|                                 | Quantitative Reasoning               | 3       |
|                                 | Information Technology and Computing | 3       |
| <b>Exploration Requirements</b> |                                      |         |
|                                 | Arts                                 | 3       |
|                                 | Global Understanding                 | 3       |
|                                 | Literature                           | 3       |
|                                 | Natural Science                      | 7       |
|                                 | Social and Behavioral Sciences       | 3       |
|                                 | Western Civilization/World History   | 3       |
| <b>Integration Requirements</b> |                                      |         |
|                                 | Written Communications (ENGH 302)    | 3       |
|                                 | Writing-Intensive <sup>1</sup>       | 3       |
|                                 | Synthesis/Capstone <sup>2</sup>      | 3       |
| Total Credits                   |                                      | 40      |

<sup>1</sup> Most programs include the writing-intensive course designated for the major as part of the major requirements; this course is therefore not counted towards the total required for Mason Core.<sup>2</sup> Minimum 3 credits required.

## Honors

### Honors in the Major

Physics majors who have maintained an overall GPA of at least 3.50 in physics courses and a GPA of 3.50 in all courses taken at George Mason University may apply to the physics honors program when they complete the first semester of their junior year.

To graduate with honors in physics, a student is required to maintain a minimum GPA of 3.00 in physics courses and successfully complete PHYS 405 Honors Thesis in Physics I and PHYS 406 Honors Thesis in Physics II with a GPA of at least 3.50 and a grade of at least 'A-' in PHYS 406 Honors Thesis in Physics II. Please visit the department for details.

## Accelerated Master's

### Physics, BS/Curriculum and Instruction, Accelerated MEd (Secondary Education Physics concentration)

#### Overview

Highly-qualified undergraduates may be admitted to the bachelor's/accelerated master's program and obtain both a BS in Physics and an MEd in Curriculum and Instruction, Secondary Education Physics Concentration in an accelerated time-frame after satisfactory completion of 149 credits. See AP.6.7 Bachelor's/Accelerated Master's Degrees for policies related to this program.

This accelerated option is offered jointly by the department of Physics and Astronomy and the Graduate School of Education.

Students in an accelerated degree program must fulfill all university requirements for the master's degree. For policies governing all graduate degrees, see AP.6 Graduate Policies.

#### Application Requirements

Applicants to all graduate programs at George Mason University must meet the admission standards and application requirements for graduate study as specified in Graduate Admissions Policies. For information specific to this accelerated master's program, see Application Requirements and Deadlines (<https://cehd.gmu.edu/bachelors-accelerated-masters-program>).

#### Accelerated Option Requirements

Students complete the following courses in their senior year.

| Senior        |         |                 |         |
|---------------|---------|-----------------|---------|
| Fall Semester | Credits | Spring Semester | Credits |
| EDCI 573      | 3       | EDCI 673        | 3       |
| EDUC 672      | 3       | EDRD 619        | 3       |
|               | 6       |                 | 6       |

Total Credits 12

While undergraduate students, accelerated master's students are able to apply two of the courses listed above to both the bachelor's and master's degrees. These courses are considered advanced standing

for the MEd. A minimum grade of B must be earned to be eligible to count as advanced standing. The other two courses are taken as reserve graduate credit and do not apply to the undergraduate degree. Early in their final undergraduate semester, students must submit the Bachelor's/Accelerated Master's Transition Form to the CEHD Admissions Office and specify which of the four courses are to be designated as advanced standing and reserve graduate credit.

### Physics, BS/Applied and Engineering Physics, Accelerated MS

#### Overview

This program allows academically strong undergraduates with a demonstrable commitment to research to obtain the Physics, BS and Applied and Engineering Physics, MS degrees by successfully completing 144 credits. Upon completion, students are well-prepared for entry into a professional school or a PhD program in physics or a related discipline.

Admitted students take selected graduate courses during their senior year and are able to use up to 6 graduate credits in partial satisfaction of requirements for the undergraduate degree. Upon completion and conferral of the bachelor's degree and with satisfactory performance (grade of 'B' or better) in each of the graduate courses, students are given advanced standing in the master's program and complete an additional 24 credits to receive the master's degree.

For more detailed information, see AP.6.7 Bachelor's/Accelerated Master's Degrees. For policies governing all graduate degrees, see AP.6 Graduate Policies.

#### Application Requirements

Applicants to all graduate programs at George Mason University must meet the admission standards and application requirements for graduate study as specified in the Graduate Admission Policies section of this catalog.

Successful applicants will have completed at least 90 credits toward their undergraduate degree and 45 credits in physics major coursework. The physics major GPA must be at least 3.50. One or more recommendation letters from one or more research supervisors are also required. Interested applicants should submit a letter to the undergraduate physics coordinator requesting admission along with the aforementioned recommendation letter(s). Contact the physics undergraduate or graduate coordinator for further details.

#### Accelerated Option Requirements

At the beginning of the student's final undergraduate semester, students must submit a bachelor's/accelerated master's transition form (<http://registrar.gmu.edu/forms>) to the College of Science's Office of Academic and Student Affairs (<https://cos.gmu.edu/about/contact-us>). Students must begin their master's program in the semester immediately following conferral of the bachelor's degree.

Students must maintain an overall GPA of 3.00 or higher in graduate coursework.

#### Reserve Graduate Credit

While still in undergraduate status, a maximum of 6 additional graduate credits may be taken as reserve graduate credit and applied to the

master's program. Reserve graduate credits do not apply to the undergraduate degree.