Physics
Charles I. Sukenik, Chair
Charles E. Hyde, Chief Departmental Advisor
Stephen Bueltmann, Associate Departmental Advisor

Bachelor of Science - Physics Major
The Department of Physics offers a major in physics with five program concentrations leading to the B.S. degree and the B.S. degree with honors.

- Concentration A (Research) is designed primarily for students preparing to do graduate study in physics and related fields or for students preparing to work professionally upon completion of the B.S. degree in various technical fields requiring the strongest preparation in physics.
- Concentration B (Professional) is designed for students who wish to create a specialized program of study which combines a strong foundation in physics with strong preparation in another field. Such other fields include engineering, medicine, computer science, business, and communications, to name a few.
- Concentration C (Education) is designed for students who are preparing to be high school physics teachers. This curriculum provides a solid foundation in both contemporary physics and in education pedagogy.
- Concentration D is a five-year, dual degree program in physics and electrical engineering. Students will receive a B.S. and B.S.E.E. upon graduation. Concentration D provides the highest level of preparation for both graduate school and positions in industry.
- Concentration E is a Bachelor of Science in physics and Master of Business Administration dual degree program. After students have satisfactorily completed their undergraduate requirements, they complete the remaining requirements in the M.B.A. program. Students must earn a minimum of 150 credits (120 for the undergraduate degree and 30 for the graduate degree).

Degree Requirements
Are comprised of three components:
1. Lower-level general education requirements.
2. Departmental requirements.
3. Upper-level general education requirements.

Some departmental requirements also satisfy upper- or lower-level general education requirements. Students earning the A.S., A.A., or A.A.S. (university parallel) degree from a Virginia Community College or Richard Bland College automatically satisfy the lower-level general education requirements. For Concentrations A and B, the upper-level general education requirement can be satisfied by any University-approved second major, minor, or two upper-division courses (6 credits) from outside the College of Sciences and not required by the major. For Concentration C, the upper-level general education requirement is satisfied by the Secondary Education Endorsement. For Concentration D, the second degree in electrical engineering satisfies the upper-level general education requirement, while for Concentration E, the M.B.A. core curriculum satisfies the upper-level general education requirement.

Graduation Requirements
All concentrations require completion of a minimum of 120 credit hours (150 credit hours for Concentration D), which must include both a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University, completion of ENGL 110C, ENGL 211C or 221C or 231C, and the writing intensive (W) course in the major with a grade of C or better, completion of the Physics Exit Exam with a minimum score of 20th percentile, and Senior Assessment. Additional hours may be required to meet the foreign language requirement. All concentrations require a minimum grade of C in PHYS 231N-PHYS 232N. Concentrations A, B, D and E require a minimum cumulative grade point average of 2.00 overall and in the major. Concentration C requires a minimum 2.75 grade point average overall, in the major, and in the professional education core, with no grade less than a C- in the major and professional education core. The professional education core satisfies the upper-level general education requirement.

Math Minor
Physics majors in Concentrations A or B wishing to complete a minor in applied mathematics can do so with just two additional math courses. Please consult the Department of Mathematics section of the Catalog for details.

Lower Level General Education Requirements
(Concentrations A, B, C, E; for concentration D refer to the electrical and computer engineering section in the College of Engineering and Technology)

Skills
Composition (grade of C or better required in both courses)
ENGL 110C English Composition 3
ENGL 211C English Composition 3
or ENGL 231C Introduction to Technical Writing
Oral Communication
COMM 101R Public Speaking 3
or COMM 103R Voice and Diction
or COMM 112R Introduction to Interpersonal Communication
Mathematics (Satisfied by major)
Language and Culture (B.S. students’ competence must be at the 102 level. High school credit may satisfy the requirement.) 0-6
Information Literacy and Research
CS 120G Introduction to Information Literacy and Research 3
or CS 121G Introduction to Information Literacy and Research for Scientists
Ways of Knowing
Human Creativity
Select one of the following: 3
ARTH 121A Introduction to the Visual Arts
ARTS 122A Visual Communication
COMM/THEA 270A Film Appreciation
DANC 185A Dance and Its Audience
MUSC 264A Music in History and Culture
THEA 241A The Theatre Experience
Interpreting the Past
Select one of the following: 3
HIST 100H Interpreting the World Past Since 1500
HIST 101H Interpreting the Asian Past
HIST 102H Interpreting the European Past
HIST 103H Interpreting the Latin America Past
HIST 104H Interpreting the American Past
HIST 105H Interpreting the African Past
Literature
Select one of the following: 3
ENGL 112L Introduction to Literature
ENGL 114L American Writers, American Experiences
FLET 100L Understanding World Literature
Philosophy and Ethics
Select one of the following: 3
PHIL 110P Introduction to Philosophy
PHIL 120P Logic and Philosophy
PHIL 230E Introduction to Ethics
PHIL 250E World Religions: Beliefs and Values

Old Dominion University 1
### Departmental Requirements for Research Concentration (A)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>MATH 211</td>
<td>Calculus I</td>
<td>4</td>
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<tr>
<td>MATH 212</td>
<td>Calculus II</td>
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<tr>
<td>MATH 312</td>
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<td>or MATH 285</td>
<td>Transfer Credit for Calculus III</td>
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<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
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<tr>
<td>or MATH 280</td>
<td>Transfer Credit for Ordinary Differential Equations</td>
<td>3</td>
</tr>
</tbody>
</table>

Select one of the following:  

- MATH 316 Introductory Linear Algebra  
- MATH 401 Partial Differential Equations  
- MATH 421 Applied Mathematics II: Mathematical Modeling  
- MATH 422 Applied Complex Variables

#### CHEM 121N & CHEM 122N  
Foundations of Chemistry I Lecture and Foundations of Chemistry I Laboratory  

- CHEM 123N & CHEM 124N  
Foundations of Chemistry II Lecture and Foundations of Chemistry II Laboratory  

- CS 150  
Problem Solving and Programming I  

- PHYS 231N  
University Physics  

- PHYS 232N  
University Physics  

- PHYS 303  
Intermediate Experimental Physics  

- PHYS 319  
Analytical Mechanics  

- PHYS 323  
Modern Physics  

- PHYS 355  
Mathematical Methods of Physics  

- PHYS 413  
Methods of Experimental Physics  

- PHYS 420  
Introductory Computational Physics  

- PHYS 425  
Electromagnetism I  

- PHYS 452  
Introduction to Quantum Mechanics  

- PHYS 453  
Electromagnetism II  

- PHYS 454  
Thermal and Statistical Physics  

- PHYS 456  
Intermediate Quantum Mechanics  

- PHYS 499W  
Senior Thesis **  

or PHYS 489W & PHYS 490W  
Senior Thesis I and Senior Thesis II  

- PHYS 120  
Physics in the 21st Century, ECE 111 is for students considering Physics Track D  

or PHYS 309  
Physics on the Back of an Envelope  

or ECE 111  
Information Literacy and Research for Electrical and Computer Engineering  

Select two of the following:  

- PHYS 313  
Elements of Astrophysics  

- PHYS 411  
Introduction to Atomic Physics  

- PHYS 415  
Introduction to Nuclear and Particle Physics  

- PHYS 416  
Introduction to Solid State Physics  

- PHYS 417  
Introduction to Particle Accelerator Physics  

* CHEM 137N/CHEM 138N may be taken instead of CHEM 121N/CHEM 122N and CHEM 123N/CHEM 124N  

** Grade of C or better required in PHYS 499W or both PHYS 489W and PHYS 490W  

*** With at least three credits at the 400-level.

### Departmental Requirements for Professional Concentration (B)

<table>
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<tr>
<td>MATH 212</td>
<td>Calculus II</td>
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</table>

**Total Hours:** 30-36
Due to changing University requirements, national accreditation standards, and the Virginia Board of Education licensure regulations, the teacher preparation programs in the College of Sciences are under constant revision. Any changes resulting from these factors supersede the program requirements described in this Catalog. Students are encouraged to obtain current program information from their advisors and the Teacher Education Services website at http://education.odu.edu/tes/.

Admission

Students must first declare the physics (Concentration C) teacher preparation concentration as their major with the physics departmental advisor. All students must apply for and be admitted into the approved physics teacher preparation program. Students must meet the required criteria for admission by passing the Virginia Board of Education prescribed assessments and earn the minimum required grade point averages (GPA).

Virginia Board of Education prescribed assessments:

Old Dominion University students seeking admission to an approved teacher education program must satisfy the Virginia Board of Education Required Assessment for Admission to an Approved Teacher Education Program. This requirement can be satisfied by meeting a passing score in one of the selected criteria below:

1. Passing PRAXIS I composite score of 532 by December 31, 2013; or
2. Passing PRAXIS Core Academic Skills Tests beginning January 1, 2014:
   - Reading Score of 156, Writing Score of 162, and Mathematics Score of 150; or
3. Approved substitute test scores:
   a. SAT score of 1000 with at least 450 verbal and 510 mathematics taken prior to April 1, 1995; or
   b. SAT score of 1100 with at least 530 verbal and 530 mathematics taken after April 1, 1995; or
   c. ACT composite score of 21 with ACT mathematics score of at least 21, and ACT English plus Reading score of at least 37, taken prior to April 1, 1995; or
   d. ACT composite score of 24 with ACT mathematics score of at least 22, and ACT English plus Reading score of at least 46, taken after April 1, 1995; or
   e. PRAXIS I Math test score of 178 by December 31, 2013 and a composite Virginia Communication and Literacy Assessment (hereafter referred to as the VCLA) score of 470; or
   f. PRAXIS Core Academic Skills Mathematics test score of 150 beginning January 1, 2014 and a VCLA score of 470; or
   g. SAT Mathematics test score of at least 510 taken prior to April 1, 1995 and a VCLA score of 470; or
   h. SAT Mathematics test score of at least 510 taken after April 1, 1995 and a composite VCLA score of 470; or
   i. ACT Mathematics test score of at least 21 taken prior to April 1, 1995 and a composite VCLA score of 470; or
   j. ACT Mathematics test score of at least 22 taken after April 1, 1995 and a composite VCLA score of 470.

Note: ACT scores taken prior to 1989 are not valid.

For the most current information on the prescribed Virginia Board of Education admission assessment, visit the Teacher Education Services website, http://www.odu.edu/tes and review the Teacher Education Handbook.

Required Grade Point Averages (GPA)

- A cumulative GPA of 2.75 is required.
- A major/content GPA of 2.75 is required - all physics courses and all other science content courses must be passed with a grade of C- or higher.
- A professional education GPA of 2.75 is required – all professional education courses must be passed with a grade of C- or higher.

Although students may enroll in a limited number of education courses, students must be admitted into the approved physics teacher preparation program prior to enrolling in any instructional strategies practicum education

### Elective Credit

Elective credit may be needed to meet the minimum requirement of 120 credit hours.

### Bachelor of Science - Physics Major with Teacher Education Licensure

Due to changing University requirements, national accreditation standards, and the Virginia Board of Education licensure regulations, the teacher

<table>
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<td>Transfer Credit for Calculus III</td>
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<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
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<tr>
<td>or MATH 280</td>
<td>Transfer Credit for Ordinary Differential Equations</td>
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<td>Select one of the following:</td>
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<tr>
<td>MATH 316</td>
<td>Introductory Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>MATH 401</td>
<td>Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MATH 421</td>
<td>Applied Mathematics II: Mathematical Modeling</td>
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<tr>
<td>MATH 422</td>
<td>Applied Complex Variables</td>
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<td>CHEM 121N</td>
<td>Foundations of Chemistry I Lecture</td>
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<td>&amp; CHEM 122N</td>
<td>and Foundations of Chemistry I Laboratory</td>
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<tr>
<td>CHEM 123N</td>
<td>Foundations of Chemistry II Lecture</td>
<td>4</td>
</tr>
<tr>
<td>&amp; CHEM 124N</td>
<td>and Foundations of Chemistry II Laboratory *</td>
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</tr>
<tr>
<td>CS 150</td>
<td>Problem Solving and Programming I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 231N</td>
<td>University Physics</td>
<td>4</td>
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<tr>
<td>PHYS 232N</td>
<td>University Physics</td>
<td>4</td>
</tr>
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<td>PHYS 323</td>
<td>Modern Physics</td>
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<td>PHYS 319</td>
<td>Analytical Mechanics</td>
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<td>PHYS 303</td>
<td>Intermediate Experimental Physics</td>
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</tr>
<tr>
<td>PHYS 355</td>
<td>Mathematical Methods of Physics</td>
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<td>PHYS 413</td>
<td>Methods of Experimental Physics</td>
<td>3</td>
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<tr>
<td>PHYS 425</td>
<td>Electromagnetism I</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 452</td>
<td>Introduction to Quantum Mechanics</td>
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<tr>
<td>PHYS 454</td>
<td>Thermal and Statistical Physics</td>
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<td>Select one of the following:</td>
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<td>PHYS 420</td>
<td>Introductory Computational Physics</td>
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<td>PHYS 453</td>
<td>Electromagnetism II</td>
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<td>PHYS 456</td>
<td>Intermediate Quantum Mechanics</td>
<td></td>
</tr>
<tr>
<td>PHYS 499W</td>
<td>Senior Thesis **</td>
<td>3</td>
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<tr>
<td>or PHYS 489W</td>
<td>Senior Thesis I            &amp; Senior Thesis II</td>
<td></td>
</tr>
<tr>
<td>PHYS 120</td>
<td>Physics in the 21st Century</td>
<td>1</td>
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<tr>
<td>or PHYS 309</td>
<td>Physics on the Back of an Envelope</td>
<td></td>
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<tr>
<td>Select two of the following:</td>
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<tr>
<td>PHYS 311</td>
<td>Color in Nature and Art</td>
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<tr>
<td>PHYS 313</td>
<td>Elements of Astrophysics</td>
<td></td>
</tr>
<tr>
<td>PHYS 332</td>
<td>Physics of Music and Musical Reproduction</td>
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<tr>
<td>PHYS 411</td>
<td>Introduction to Atomic Physics</td>
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<td>PHYS 415</td>
<td>Introduction to Nuclear and Particle Physics</td>
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<td>PHYS 416</td>
<td>Introduction to Solid State Physics</td>
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<tr>
<td>PHYS 417</td>
<td>Introduction to Particle Accelerator Physics</td>
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</table>

Total Hours 75

* CHEM 137N and CHEM 138N may be used instead of CHEM 121N/CHM 122N and CHEM 123N/CHM 124N.
** Grade of C or better required in PHYS 499W or both PHYS 489W and PHYS 490W.
*** With at least three credits at the 400-level.
course. Students must also meet with an education advisor in the Office of Teacher Education Services.

**Continuance**

Students must maintain a cumulative GPA of 2.75, a major/content GPA of 2.75 and a professional education GPA of 2.75. Physics courses must be passed with a grade of C- or higher. The remaining courses required for the major and in the professional education core must be completed with a grade of C- or higher for continuance. A professional education GPA of 2.75 is required for continuance. Students must take and pass the Virginia Communication and Literacy Assessment (VCLA) and the PRAXIS II Physics Content examination prior to or while enrolled in the instructional strategies course. All assessments must be passed prior to the start of the Teacher Candidate Internship Orientation session.

**Background Clearance Requirement**

Old Dominion University requires a background clearance check of candidates interested in many of the professional education programs. Professional education programs have several field experiences that are required for continuance and graduation from the program. The background clearance must be successfully completed prior to a field experience placement. Candidates will be provided a field experience placement when the background check process is completed with resolution of any issues. The process to complete the ODU background clearance check is located at: http://www.odu.edu/success/academic/teacher-education/placement/background-checks. The ODU clearance process includes an FBI fingerprint, a child protective service/social service review, and a Virginia State Police sex offender registry review. Candidates interested in the professional education programs are advised to complete this clearance process immediately upon entry into the program since the clearance process takes a minimum of eight weeks to complete.

**Virginia Board of Education prescribed assessments**

Virginia Communication and Literacy Assessment (VCLA) – a passing composite score of 470 is required on this reading and writing assessment

PRAXIS II Physics: Content Knowledge (test code: 0265 or 5265) – passing score of 147 is required

PRAXIS II Reading and Writing (test code: 0156) – passing score of 47 on this reading and writing assessment

**Virginia Communication and Literacy Assessment (VCLA)** – a passing score of 147 is required

To review more information on the Virginia Board of Education prescribed assessments visit the Teacher Education Services website, www.odu.edu/tes.

**Graduation**

Requirements for graduation include completion of ENGL 110C, ENGL 211C or 221C or 231C, and the writing intensive (W) course in the major with a grade of C or better, completion of the Senior Assessment, completion of the Physics Exit Exam with a minimum score of 20th percentile, a minimum cumulative 2.75 GPA, in the major area, and in the professional education core, with no grade less than a C- in the major and the professional education core; successful completion of the Teacher Candidate Internship and a minimum of 120 credit hours, which must include both a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University.

The curriculum is as follows:

**Departmental Requirements for Education**

**Concentration (C)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH 211</td>
<td>Calculus I</td>
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<td>MATH 212</td>
<td>Calculus II</td>
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<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
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<td>or MATH 280</td>
<td>Transfer Credit for Ordinary Differential Equations</td>
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<tr>
<td>CHEM 121N</td>
<td>Foundations of Chemistry I Lecture</td>
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<td>&amp; CHEM 122N</td>
<td>and Foundations of Chemistry I Laboratory</td>
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<tr>
<td>CHEM 123N</td>
<td>Foundations of Chemistry II Lecture</td>
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</tr>
<tr>
<td>&amp; CHEM 124N</td>
<td>and Foundations of Chemistry II Laboratory</td>
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<td>CS 150</td>
<td>Problem Solving and Programming I</td>
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</tr>
<tr>
<td>PHYS 103N</td>
<td>Introductory Astronomy of the Solar System</td>
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<tr>
<td>or PHYS 104N</td>
<td>Introductory Astronomy of Galaxies and Cosmology</td>
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<td>PHYS 231N</td>
<td>University Physics</td>
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<td>PHYS 499W</td>
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<td>or PHYS 489W</td>
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<tr>
<td>&amp; PHYS 490W</td>
<td>and Senior Thesis II</td>
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</table>

**Total Hours**: 57

* CHEM 137N/CHEM 138N may be taken instead of CHEM 121N/CHEM 122N and CHEM 123N/CHEM 124N

**Virginia Board of Education prescribed assessments**

Virginia Communication and Literacy Assessment (VCLA) – a passing composite score of 470 is required on this reading and writing assessment

PRAXIS II Physics: Content Knowledge (test code: 0265 or 5265) – passing score of 147 is required

PRAXIS II Reading and Writing (test code: 0156) – passing score of 47 on this reading and writing assessment

**The Professional Education Core Courses and Requirements**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<td>STEM 101</td>
<td>Step 1 – Inquiry Approaches to Teaching</td>
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<td>STEM 102</td>
<td>Step 2 - Inquiry Based STEM Lesson Design</td>
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<td>STEM 201</td>
<td>Knowing and Learning in STEM Education</td>
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<td>STEM 202</td>
<td>Classroom Interactions in STEM Education</td>
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<td>Project Based Instruction in STEM Education</td>
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<td>STEM 485</td>
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<td>STEM 402</td>
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<tr>
<td>SCI 468</td>
<td>Research Methods in Math and Sciences</td>
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**Total Hours**: 26

**Bachelor of Science - Dual Degree: Bachelor of Science in Physics and Bachelor of Science in Electrical Engineering**

**Departmental Requirements for Concentration D (Dual Degree in Physics and Electrical Engineering)**

**Common Course Requirements**

**Approved Physics Seminar**

<table>
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<tr>
<th>Course Code</th>
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<tr>
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<td>MATH 211</td>
<td>Calculus I</td>
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<tr>
<td>MATH 312</td>
<td>Calculus III</td>
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<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
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<tr>
<td>CS 150</td>
<td>Problem Solving and Programming I</td>
<td>4</td>
</tr>
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<td>PHYS 231N</td>
<td>University Physics</td>
<td>4</td>
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<td>PHYS 232N</td>
<td>University Physics</td>
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<td>PHYS 233N</td>
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**Physics Course Requirements**

<table>
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<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 123N</td>
<td>Foundations of Chemistry II Lecture</td>
<td>4</td>
</tr>
<tr>
<td>&amp; CHEM 124N</td>
<td>and Foundations of Chemistry II Laboratory</td>
<td>4</td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 316</td>
<td>Introductory Linear Algebra</td>
<td>3</td>
</tr>
</tbody>
</table>
MATH 401  Partial Differential Equations
MATH 421  Applied Mathematics II: Mathematical Modeling
MATH 422  Applied Complex Variables

PHYS 323  Modern Physics  3
PHYS 319  Analytical Mechanics  3
PHYS 303  Intermediate Experimental Physics 3
or ECE 287  Fundamental Electric Circuit Laboratory

PHYS 425  Electromagnetism I  3
PHYS 452  Introduction to Quantum Mechanics  3
PHYS 413  Methods of Experimental Physics  3
PHYS 454  Thermal and Statistical Physics  3
PHYS 420  Introductory Computational Physics  3
PHYS 453  Electromagnetism II  3
or ECE 323  Electromagnetics

PHYS 456  Intermediate Quantum Mechanics  3
PHYS 499W  Senior Thesis  
& PHYS 489W  Senior Thesis I
& PHYS 490W  Senior Thesis II

Select one of the following:

PHYS 411  Introduction to Atomic Physics
PHYS 415  Introduction to Nuclear and Particle Physics
PHYS 416  Introduction to Solid State Physics
PHYS 417  Introduction to Particle Accelerator Physics

**Engineering Course Requirements**

ENGN 110  Explore Engineering and Technology  2
ECE 111  Information Literacy and Research for Electrical and Computer Engineering 2
ECE 201  Circuit Analysis I  3
ECE 202  Circuit Analysis II  3
ECE 241  Fundamentals of Computer Engineering  4
ECE 287  Fundamental Electric Circuit Laboratory  2
ECE 302  Linear System Analysis  3
ECE 303  Introduction to Electrical Power  3
ECE 304  Probability, Statistics, and Reliability  3
ECE 313  Electronic Circuits  4
ECE 332  Microelectronic Materials and Processes  3
ECE 381  Introduction to Discrete-time Signal Processing  3
ECE 387  Microelectronics Fabrication Laboratory  3
ECE 485W  Electrical Engineering Design I  3
ECE 486  Preparatory ECE Senior Design II  2
ECE 487  ECE Senior Design II  2
ECE Tech Elective I, II, III  9
Approved Elective  1–3

**Total Hours**  129–132

* Grade of C or better required in PHYS 499W or both PHYS 489W and PHYS 490W

**Departmental Requirements for Concentration E (B.S. Physics and M.B.A.)**

Students in this concentration must earn a minimum of 150 credit hours (120 for the undergraduate degree and 30 for the graduate degree).

**Physics Course Requirements**

MATH 211  Calculus I  4
MATH 212  Calculus II  4
MATH 312  Calculus III  4
MATH 307  Ordinary Differential Equations 3

Select one of the following:  3

**MATH 316  Introductory Linear Algebra**
MATH 401  Partial Differential Equations
MATH 421  Applied Mathematics II: Mathematical Modeling
MATH 422  Applied Complex Variables

CHEM 121N & CHEM 122N  Foundations of Chemistry I Lecture and Foundations of Chemistry I Laboratory 4

CHEM 123N & CHEM 124N  Foundations of Chemistry II Lecture and Foundations of Chemistry II Laboratory 4

CS 150  Problem Solving and Programming I  4
PHYS 231N  University Physics  4
PHYS 232N  University Physics  4
PHYS 323  Modern Physics  3
PHYS 319  Analytical Mechanics  3
PHYS 303  Intermediate Experimental Physics  3
PHYS 355  Mathematical Methods of Physics  3
PHYS 413  Methods of Experimental Physics  3
PHYS 425  Electromagnetism I  3
PHYS 452  Introduction to Quantum Mechanics  3
PHYS 454  Thermal and Statistical Physics  3

Select one of the following:

PHYS 420  Introductory Computational Physics
PHYS 453  Electromagnetism II

PHYS 456  Intermediate Quantum Mechanics

PHYS 499W  Senior Thesis
or PHYS 489W  Senior Thesis I
& PHYS 490W  Senior Thesis II

Approved Physics Seminar  1

Select one of the following:

PHYS 311  Color in Nature and Art
PHYS 313  Elements of Astrophysics
PHYS 332  Physics of Music and Musical Reproduction
PHYS 350  Light and Lasers
PHYS 411  Introduction to Atomic Physics
PHYS 415  Introduction to Nuclear and Particle Physics
PHYS 416  Introduction to Solid State Physics
PHYS 417  Introduction to Particle Accelerator Physics

**Total Hours**  72

* Or CHEM 137N-CHEM 138N
** Grade of C or better required in PHYS 499W or both PHYS 489W and PHYS 490W

**Upper Division General Education**

Satisfied by M.B.A. Pre-Core and Core Curriculum: These courses may be taken beginning with the second semester of the junior year. Students must maintain a 3.0 grade point average in these courses to continue in the program.

**MBA Pre-Core**

MBA 600  Introduction to Statistics  1
MBA 601  Introduction to Managerial Economics  1
MBA 602  Introduction to Finance  1
MBA 603  Introduction to Accounting  1
MBA 604  Introduction to Information Management  1

**MBA Core**

ACCT 609  Managerial Accounting  2
ACCT 611  Financial Accounting  2
BNAL 606  Statistics for Managers  2
BNAL 610  Fundamentals of Business Analytics  2  
ECON 607  Managerial Economics  2  
ECON 618  Global Macroeconomics  2  
FIN 613  Financial Management  2  
FIN 616  Investments and Portfolio Management  2  
FIN 619  Business Law and Ethics  2  
INBU 620  International Business Issues  2  
IT 614  Information and Knowledge Management  2  
MGMT 605  Essentials of Leadership  2  
MGMT 612  Organizational Behavior  2  
MGMT 621  Business Policy and Strategy  4  
MKTG 608  Fundamentals of Contemporary Marketing  2  
MKTG 617  Marketing Strategy  2  
OPMT 615  Operations & Supply Chain Management  2  

**Senior Thesis**

An important feature of all concentrations is the Senior Thesis, which is based on individual research done under the supervision of a faculty advisor. The Senior Thesis is a capstone experience that gives a student the opportunity to apply knowledge and skills acquired in the classroom to real-life research problems in physics. This research can be done either in on-campus laboratories and facilities or at other scientific institutions in the region where departmental faculty members perform research, such as the Thomas Jefferson National Accelerator Facility (including the Applied Research Center) or the Langley Research Center of NASA. On completion of the project, the student must prepare a written final report and make an oral presentation of the results to the department. The senior thesis can be completed in one semester, by taking PHYS 499W, or in two semesters, by taking the PHYS 489W & PHYS 490W sequence.

**Minor in Physics**

PHYS 231N-PHYS 232N must be completed as prerequisites for the minor in physics and are not included in the calculation of the grade point average for the minor. The minor in physics requires completion of the following, with an overall cumulative grade point average of 2.00 or better in these courses exclusive of 100/200 level courses and prerequisite courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 319</td>
<td>Analytical Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 323</td>
<td>Modern Physics</td>
<td>3</td>
</tr>
<tr>
<td>Two 300 or 400-level PHYS courses</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

**Total Hours**  
12

Students must complete a minimum of six credit hours of 300-level or 400-level PHYS courses in the minor requirement through courses offered by Old Dominion University. Up to three credits can be in Independent Study courses, with approval of the chief departmental advisor. Any substitutions must be approved in writing by the chief departmental advisor.

**B. S. Degree with Honors**

Qualified students may receive the B.S. degree with honors (to be noted on their diplomas) by completing specified additional requirements. At the time of application for this designation, a student must have a GPA of 3.50 or higher in physics, a GPA of 3.25 or higher overall, must have completed two contract honors courses, and must have completed 60 credit hours (of which at least 54 must be in grade-point graded courses) at Old Dominion University. (Contract honors courses are specialized courses of individual study under the direct supervision of a professor. Permission to take these courses is granted jointly by the Department of Physics and the Honors College.)

**Advanced Placement**

Advanced placement credit for PHYS 111N-PHYS 112N (four credits each, for a total of eight credits) will be awarded for a score of 4 or 5 on the Physics B examination, advanced placement credit for PHYS 231N (four credits) will be awarded for a score of 4 or 5 on the Physics C (Mechanics) examination, and advanced placement credit for PHYS 232N (four credits) will be awarded for a score of 4 or 5 on the Physics C (Electricity and Magnetism) examination, each administered by the Advanced Placement Program of the College Board.

Advanced placement credit for courses other than PHYS 111N-PHYS 112N and PHYS 231N-PHYS 232N may be received on the basis of examinations administered by the Department of Physics. Permission to take such an examination must be obtained from the chief departmental advisor. Students may also refer to the Policy on Prior Learning Assessment Credit Options at the Undergraduate Level found in this Catalog.

**Clifford L. and Lillian R. Adams Scholarship**

The Department of Physics selects one or more students each year to receive the Clifford L. and Lillian R. Adams Scholarship. The recipient must be a declared physics major and may be an entering freshman, a transfer student, or a continuing student. Selection is based on a student's academic record, relevant test scores, and recommendations. The award is renewable.