Physics

The Department of Physics also offers the program: Engineering Physics - B.Eng. Consult the Engineering program section for details about this program.

The B.Sc. Honours in Applied Physics is available with a Minor in Business. Consult the Business program section for admission and program requirements.

The Co-operative Education Option is available in conjunction with all Honours programs of the Department of Physics (see the Co-operative Education section of this Calendar for details).

Advice to Incoming Students

Students should consult with the Department when planning their program and selecting courses.

The Associate Chair for Undergraduate Studies may be contacted at undergrad-advisor@physics.carleton.ca

See www.physics.carleton.ca for advice on year by year coursework.

Students in Physics programs should normally choose PHYS 1001 and PHYS 1002 in first year.

Graduation Requirements

In addition to the program requirements listed below, students must satisfy:

1. the University regulations including the process of Academic Performance Evaluation (see the Academic Regulations of the University section of this Calendar),
2. the common regulations applying to all B.Sc. programs including those relating to Breadth requirements (see the Academic Regulations for the Bachelor of Science).

Course Categories for Physics

The program descriptions below make use of the following course categories, which are defined in the *Academic Regulations for the Bachelor of Science* section of this Calendar:

- Approved Arts or Social Sciences Elective
- Free Elective

Program Requirements

Physics (Experimental Stream)
B.Sc. Honours (20.0 credits)

A. Credits Included in the Major CGPA (11.0 credits)

1. 1.0 credit from:		1.0
PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)	
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher)	
2. 2.0 credits in:		2.0
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2305 [0.5]	Electricity and Magnetism	
PHYS 2401 [0.5]	Thermal Physics	
PHYS 2604 [0.5]	Modern Physics I	
3. 1.0 credit in:		1.0
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
4. 4.5 credits in:		4.5
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3606 [0.5]	Modern Physics II	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
PHYS 3802 [0.5]	Advanced Dynamics	
PHYS 3807 [0.5]	Mathematical Physics I	
PHYS 4409 [0.5]	Thermodynamics and Statistical Physics	
PHYS 4008 [0.5]	Fourth-Year Physics Laboratory: Selected Experiments and Workshop	
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I	
5. 1.0 credit from:		1.0
a. PHYS 4907 [0.5] plus 0.5 credit 4000-level PHYS		
b. PHYS 4908 [0.5] plus 0.5 credit 4000-level PHYS		
c. PHYS 4909 [1.0]		
6. 1.0 credit in 4000-level or above PHYS (PHYS 4807 is recommended for 0.5 credit)		1.0
7. 0.5 credit in 3000-level or above PHYS, COMP, ELEC, MATH and/or STAT		0.5

B. Credits Not Included In the Major CGPA (9.0 credits)

8. 1.0 credit from:		1.0
BIOL 1003 [0.5] & BIOL 1004 [0.5]	Introductory Biology I and Introductory Biology II	
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I and General Chemistry II	
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I and Elementary Chemistry II	
ERTH 1006 [0.5] & ERTH 1009 [0.5]	Exploring Planet Earth and The Earth System Through Time	
9. 3.0 credits in:		3.0
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
STAT 3502 [0.5]	Probability and Statistics	
10. 0.5 credit in:		0.5
MATH 3806 [0.5]	Numerical Analysis (Honours)	
11. 1.0 credit from:		1.0

COMP 1005 [0.5] & COMP 1006 [0.5]	Introduction to Computer Science I and Introduction to Computer Science II
or	
ECOR 1606 [0.5] & ECOR 2606 [0.5]	Problem Solving and Computers and Numerical Methods

12. 0.5 credit in COMP, MATH, or PHYS at the 2000-level or higher	0.5
13. 0.5 credit in:	0.5
NSCI 1000 [0.5] Seminar in Science (or Approved Arts or Social Sciences Elective)	
14. 1.5 credits in approved Arts or Social Science Electives	1.5
14. 1.0 credit in free electives	1.0
Total Credits	20.0

Physics (Theory Stream)
B.Sc. Honours (20.0 credits)

A. Credits Included in the Major CGPA (10.5 credits)

1. 1.0 credit from:		1.0
PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)	
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher)	
2. 2.0 credits in:		2.0
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2305 [0.5]	Electricity and Magnetism	
PHYS 2401 [0.5]	Thermal Physics	
PHYS 2604 [0.5]	Modern Physics I	
3. 4.5 credits in:		4.5
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3606 [0.5]	Modern Physics II	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
PHYS 3802 [0.5]	Advanced Dynamics	
PHYS 3807 [0.5]	Mathematical Physics I	
PHYS 4409 [0.5]	Thermodynamics and Statistical Physics	
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I	
PHYS 4708 [0.5]	Introduction to Quantum Mechanics II	
4. 1.0 credit from:		1.0
a. PHYS 4907 plus 0.5 credit 4000-level PHYS		
b. PHYS 4908 plus 0.5 credit 4000-level PHYS		
c. PHYS 4909 [1.0]		
5. 1.0 credit in PHYS at the 4000-level or above		1.0
6. 1.0 credit in PHYS, COMP, MATH and/or STAT at the 3000-level or above		1.0

B. Credits Not Included In the Major CGPA (9.5 credits)

7. 1.0 credit from:		1.0
BIOL 1003 [0.5] & BIOL 1004 [0.5]	Introductory Biology I and Introductory Biology II	
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I and General Chemistry II	
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I and Elementary Chemistry II	
ERTH 1006 [0.5] & ERTH 1009 [0.5]	Exploring Planet Earth and The Earth System Through Time	
8. 3.5 credits in:		3.5
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 2107 [0.5]	Linear Algebra II	
MATH 3705 [0.5]	Mathematical Methods I	
STAT 3502 [0.5]	Probability and Statistics	
9. 0.5 credit in:		0.5
MATH 3806 [0.5]	Numerical Analysis (Honours)	
10. 1.0 credit from:		1.0
COMP 1005 [0.5] & COMP 1006 [0.5]	Introduction to Computer Science I and Introduction to Computer Science II	
or		
ECOR 1606 [0.5] & ECOR 2606 [0.5]	Problem Solving and Computers and Numerical Methods	
12. 0.5 credit in COMP, MATH, or PHYS at the 2000-level or higher		0.5
13. 0.5 credit in:		0.5
NSCI 1000 [0.5]	Seminar in Science (or Approved Arts or Social Sciences Elective)	
Approved Arts or Social Sciences Electives		
14. 1.5 credits in Approved Arts or Social Science Electives		1.5
15. 1.0 credit in free electives		1.0
Total Credits		20.0

Physics
B.Sc. Major (20.0 credits)

A. Credits Included in the Major CGPA (9.0 credits)

1. 1.0 credit from:		1.0
PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)	
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher)	
2. 2.0 credits in:		2.0
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2305 [0.5]	Electricity and Magnetism	
PHYS 2401 [0.5]	Thermal Physics	

PHYS 2604 [0.5]	Modern Physics I	

3. 1.0 credit in approved computer science, engineering, mathematics or statistics electives at the 2000-level or higher which may include 0.5 credit 1000-level computer science   1.0

4. 2.0 credits in:		2.0
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3606 [0.5]	Modern Physics II	
or PHYS 3608 [0.5]	Modern Applied Physics	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	

5. 1.0 credit in PHYS at the 4000-level   1.0

6. 1.5 credit in PHYS at the 3000-level or above   1.5

7. 0.5 credit in ELEC and/or science faculty electives (excluding TSES) at the 3000-level or above   0.5

B. Credits Not Included In the Major CGPA (11.0 credits)

8. 1.0 credit from:		1.0
BIOL 1003 [0.5] & BIOL 1004 [0.5]	Introductory Biology I and Introductory Biology II	
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I and General Chemistry II	
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I and Elementary Chemistry II	
ERTH 1006 [0.5] & ERTH 1009 [0.5]	Exploring Planet Earth and The Earth System Through Time	

9. 3.0 credits in:		3.0
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
or STAT 3502 [0.5]	Probability and Statistics	

10. 0.5 credit from:		0.5
COMP 1005 [0.5]	Introduction to Computer Science I	
ECOR 1606 [0.5]	Problem Solving and Computers	

11. 3.5 credits in Advanced Science Faculty Electives and/or Approved Arts or Social Sciences Electives and/or Engineering electives selected in consultation with the Department to complement the study of physics; these credits may be used with an additional 0.5 credit to complete the requirements of a minor designation   3.5

12. 0.5 credit from:		0.5
NSCI 1000 [0.5]	Seminar in Science	
Approved Arts or Social Sciences Electives		

13. 1.5 credits in Approved Arts or Social Sciences Electives   1.5

14. 1.0 credit in free electives   1.0

Total Credits   20.0

Applied Physics
B.Sc. Honours (20.0 credits)

A. Credits Included in the Major CGPA (11.0 credits)

1. 1.0 credit from:		1.0
PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)	
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher)	

2. 2.0 credits in:		2.0
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2305 [0.5]	Electricity and Magnetism	
PHYS 2401 [0.5]	Thermal Physics	
PHYS 2604 [0.5]	Modern Physics I	

3. 1.0 credit in:		1.0
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	

4. 0.5 credit from:		0.5
ECOR 2606 [0.5]	Numerical Methods	
MATH 3806 [0.5]	Numerical Analysis (Honours)	

5. 4.0 credits in:		4.0
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3608 [0.5]	Modern Applied Physics	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
PHYS 3802 [0.5]	Advanced Dynamics	
PHYS 3807 [0.5]	Mathematical Physics I	
PHYS 4008 [0.5]	Fourth-Year Physics Laboratory: Selected Experiments and Workshop	
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I	

6. 1.0 credit from:		1.0
PHYS 3207 [0.5]	Topics in Biophysics	
PHYS 4203 [0.5]	Physical Applications of Fourier Analysis	
PHYS 4208 [0.5]	Modern Optics	
PHYS 4608 [0.5]	Nuclear Physics	
PHYS 4807 [0.5]	Computational Physics	

7. 0.5 credit from:		0.5
ELEC 3509 [0.5]	Electronics II	
ELEC 3908 [0.5]	Physical Electronics	
COMP at the 3000-level		
PHYS at the 4000-level		

8. 1.0 credit in from:	1.0
a. PHYS 4907 plus 0.5 credit 4000-level PHYS	
b. PHYS 4908 plus 0.5 credit 4000-level PHYS	
c. PHYS 4909 [1.0]	

B. Credits Not Included in the Major CGPA (9.0 credits)

9. 1.0 credit from: 1.0

BIOL 1003 [0.5] & BIOL 1004 [0.5]	Introductory Biology I and Introductory Biology II	
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I and General Chemistry II	
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I and Elementary Chemistry II	
ERTH 1006 [0.5] & ERTH 1009 [0.5]	Exploring Planet Earth and The Earth System Through Time	

10. 3.0 credits in: 3.0

MATH 1004 [0.5]	Calculus for Engineering or Physics
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics
MATH 1104 [0.5]	Linear Algebra for Engineering or Science
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics
STAT 3502 [0.5]	Probability and Statistics
MATH 3705 [0.5]	Mathematical Methods I

11. 0.5 credit from: 0.5

COMP 1005 [0.5]	Introduction to Computer Science I
ECOR 1606 [0.5]	Problem Solving and Computers

12. 4.0 credits in: (Business minor students see Notes, below):   4.0

a. (COMP 1006 and COMP 2401) or (SYSC 2006 and SYSC 2004)

b. 1.5 credits in Approved Arts or Social Sciences Electives

c. 1.5 credit in free electives

13. 0.5 credit from: 0.5

NSCI 1000 [0.5]	Seminar in Science

Approved Arts or Social Sciences Electives (See Note 2, below)

Total Credits	20.0

Notes:

1. For Item 12 above students admitted to the Business Minor for Applied Physics may substitute the requirements listed in a), b) and c) with the requirements for a Minor in Business. Consult the Business section of this Calendar for requirements.

2. Students in the Business Minor for Applied Physics may also select a BUSI course or a free elective to fulfill Item 13.

Mathematics and Physics
B.Sc. Double Honours (21.5 credits)

Note that the following courses have minimum grade requirements in their prerequisites. Refer to the section Course Prerequisites under the Mathematics and Statistics programs sections of the calendar.

MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)	1.0
MATH 2100 [1.0]	Algebra II (Honours)	1.0
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)	0.5
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)	0.5

A. Credits Included in the Major CGPA (17.5 credits)

1. 7.5 credits in: 7.5

MATH 1002 [1.0]	Calculus and Introductory Analysis I
MATH 1102 [1.0]	Algebra I
MATH 1800 [0.5]	Introduction to Mathematical Reasoning
MATH 2000 [1.0]	Calculus and Introductory Analysis II (Honours)
MATH 2100 [1.0]	Algebra II (Honours)
MATH 2454 [0.5]	Ordinary Differential Equations (Honours)
STAT 2655 [0.5]	Introduction to Probability with Applications (Honours)
MATH 3705 [0.5]	Mathematical Methods I
MATH 3001 [0.5]	Real Analysis I (Honours)
MATH 3057 [0.5]	Functions of a Complex Variable (Honours)
MATH 3106 [0.5]	Introduction to Group Theory (Honours)

2. 0.5 credit from: 0.5

MATH 3002 [0.5]	Real Analysis II (Honours)
MATH 3003 [0.5]	Advanced Differential Calculus (Honours)
MATH 3008 [0.5]	Ordinary Differential Equations (Honours)

3. 1.0 credit in 4000-level or higher MATH, STAT   1.0

4. 1.0 credit from: 1.0

PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher)

5. 2.0 credits in: 2.0

PHYS 2202 [0.5]	Wave Motion and Optics
PHYS 2305 [0.5]	Electricity and Magnetism
PHYS 2401 [0.5]	Thermal Physics
PHYS 2604 [0.5]	Modern Physics I

6. 3.5 credits in: 3.5

PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars
PHYS 3308 [0.5]	Electromagnetism
PHYS 3701 [0.5]	Elements of Quantum Mechanics
PHYS 3802 [0.5]	Advanced Dynamics
PHYS 4409 [0.5]	Thermodynamics and Statistical Physics
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I
PHYS 4708 [0.5]	Introduction to Quantum Mechanics II

7. 1.0 credit from: PHYS 3606 [0.5] and 0.5 credit in PHYS at the 4000-level, OR 1.0 credit in PHYS at the 4000-level   1.0

8. 1.0 credit from: 1.0

    a. MATH 4905 or PHYS 4907 or PHYS 4908 plus 0.5 credit 4000-level MATH or PHYS

    b. PHYS 4909 [1.0]

B. Credits Not Included in the Major CGPA (4.0 credits)

9. 1.0 credit from: 1.0

BIOL 1003 [0.5] & BIOL 1004 [0.5]	Introductory Biology I and Introductory Biology II
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I and General Chemistry II
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I and Elementary Chemistry II
ERTH 1006 [0.5] & ERTH 1009 [0.5]	Exploring Planet Earth and The Earth System Through Time

10. 1.0 credit in: 1.0

COMP 1005 [0.5]	Introduction to Computer Science I
COMP 1006 [0.5]	Introduction to Computer Science II

11. 0.5 credit from: 0.5

NSCI 1000 [0.5]	Seminar in Science
Approved Arts or Social Sciences	

12. 1.5 credits in Approved Arts or Social Sciences Electives   1.5

Total Credits	21.5

Note: in Item 3 above, MATH 4003 is highly recommended.

Biology and Physics
B.Sc. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (12.0 credits)

1. 1.0 credit from: 1.0

PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher)

2. 2.0 credits in: 2.0

PHYS 2604 [0.5]	Modern Physics I
PHYS 2202 [0.5]	Wave Motion and Optics
PHYS 2305 [0.5]	Electricity and Magnetism
PHYS 2401 [0.5]	Thermal Physics

3. 2.0 credits in: 2.0

PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars
PHYS 3207 [0.5]	Topics in Biophysics
PHYS 3606 [0.5]	Modern Physics II
PHYS 3701 [0.5]	Elements of Quantum Mechanics

4. 1.0 credit from: 1.0

PHYS 3308 [0.5]	Electromagnetism
PHYS 3802 [0.5]	Advanced Dynamics
PHYS 3807 [0.5]	Mathematical Physics I
PHYS 4008 [0.5]	Fourth-Year Physics Laboratory: Selected Experiments and Workshop
PHYS 4203 [0.5]	Physical Applications of Fourier Analysis
PHYS 4409 [0.5]	Thermodynamics and Statistical Physics
PHYS 4608 [0.5]	Nuclear Physics
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I

5. 4.0 credits in: 4.0

BIOL 1103 [0.5]	Foundations of Biology I
BIOL 1104 [0.5]	Foundations of Biology II
BIOL 2200 [0.5]	Cellular Biochemistry
BIOL 2104 [0.5]	Introductory Genetics
BIOL 2001 [0.5]	Animals: Form and Function
BIOL 3201 [0.5]	Cell Biology
BIOL 3104 [0.5]	Molecular Genetics
BIOL 3305 [0.5]	Human and Comparative Physiology

6. 1.0 credit from: 1.0

BIOL 4106 [0.5]	Advances in Molecular Biology
BIOL 4109 [0.5]	Laboratory Techniques in Molecular Genetics
BIOL 4202 [0.5]	Mutagenesis and DNA Repair
BIOL 4301 [0.5]	Current Topics in Biotechnology
BIOL 4306 [0.5]	Animal Neurophysiology

7. 1.0 credit from: 1.0

    a. BIOL 4907 [1.0]

    b. BIOL 4908 [1.0]

    c. PHYS 4909 [1.0]

    d. PHYS 4907 [0.5] plus 0.5 credit 4000-level PHYS

    e. PHYS 4908 plus 0.5 credit 4000-level PHYS

B. Credits Not Included in the Major CGPA (8.0 credits)

8. 1.0 credit in: 1.0

CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I and General Chemistry II (See Note, below)

9. 1.5 credit from: 1.5

MATH 1004 [0.5]	Calculus for Engineering or Physics
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics
MATH 1104 [0.5]	Linear Algebra for Engineering or Science

10. 2.0 credits in: 2.0

STAT 2507 [0.5]	Introduction to Statistical Modeling I
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics
MATH 3705 [0.5]	Mathematical Methods I
MATH 3806 [0.5]	Numerical Analysis (Honours)

11. 0.5 credit from: 0.5

COMP 1005 [0.5]	Introduction to Computer Science I

12. 0.5 credit from: 0.5

NSCI 1000 [0.5]	Seminar in Science
Approved Arts or Social Sciences Elective	

13. 1.5 credits in Approved Arts or Social Sciences   1.5

14. 1.0 credit in free electives   1.0

Total Credits	20.0

Note: For **Item 8** above, CHEM 1001 and CHEM 1002 are strongly recommended for this program. Students may substitute CHEM 1001 and CHEM 1002 with CHEM 1005 and CHEM 1006, respectively. Students choosing CHEM 1005 and CHEM 1006 will be required to obtain a grade of B- or higher in CHEM 1006 to take BIOL 2200 and more advanced courses in BIOC and CHEM. Students completing CHEM 1005 with a grade of B- or higher are encouraged to register for CHEM 1002.

Chemistry and Physics
B.Sc. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (13.0 credits)

1. 1.0 credit from:		1.0
PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I and Foundations of Physics II (recommended)	
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics and Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I and Elementary University Physics II (with an average grade of B- or higher)	

2. 3.0 credits in:		3.0
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2305 [0.5]	Electricity and Magnetism	
PHYS 2604 [0.5]	Modern Physics I	
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
PHYS 3807 [0.5]	Mathematical Physics I	

3. 1.5 credits from:		1.5
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3606 [0.5]	Modern Physics II	
PHYS 3802 [0.5]	Advanced Dynamics	
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I	

4. 0.5 credit in PHYS at the 4000-level		0.5

5. 4.5 credits in:		4.5
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
CHEM 2103 [0.5]	Physical Chemistry I	
CHEM 2203 [0.5]	Organic Chemistry I	
CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
CHEM 3100 [0.5]	Physical Chemistry II	
CHEM 3102 [0.5]	Methods of Computational Chemistry	
CHEM 3503 [0.5]	Inorganic Chemistry I	
CHEM 4102 [0.5]	Advanced Topics in Physical Chemistry II	

6. 0.5 credit from:		0.5
CHEM 2204 [0.5]	Organic Chemistry II	
CHEM 2206 [0.5]	Organic Chemistry IV	

7. 0.5 credit from:		0.5

CHEM 3106 [0.5]	Computational Chemistry Methods Laboratory	
CHEM 3107 [0.5]	Experimental Methods in Nanoscience	

8. 0.5 credit in CHEM at the 4000-level		0.5
9. 1.0 credit from:		1.0
a. CHEM 4908 [1.0]		
b. PHYS 4909 [1.0]		
c. PHYS 4907 plus 0.5 credit 4000-level PHYS		
d. PHYS 4908 plus 0.5 credit 4000-level PHYS		

B. Credits Not Included in the Major CGPA (7.0 credits)

10. 3.0 credits in:		3.0
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
STAT 3502 [0.5]	Probability and Statistics	
MATH 3705 [0.5]	Mathematical Methods I	

11. 0.5 credit from:		0.5
COMP 1005 [0.5]	Introduction to Computer Science I	
ECOR 1606 [0.5]	Problem Solving and Computers	

12. 0.5 credit from:		0.5
MATH 3806 [0.5]	Numerical Analysis (Honours)	
ECOR 2606 [0.5]	Numerical Methods	

13. 0.5 credit from:		0.5
NSCI 1000 [0.5]	Seminar in Science	
Approved Arts or Social Sciences elective		

14. 1.5 credits in Approved Arts or Social Sciences electives		1.5
15. 1.0 credit in free electives		1.0

Total Credits	20.0

Minor in Physics (4.0 credits)

The Minor in Physics is available to students registered in degree programs other than those offered by the Department of Physics. Careful attention must be paid to prerequisites.

Requirements

1. 0.5 credit from:		0.5
PHYS 1001 [0.5]	Foundations of Physics I	
PHYS 1003 [0.5]	Introductory Mechanics and Thermodynamics	
PHYS 1007 [0.5]	Elementary University Physics I (see note below)	

2. 0.5 credit from:		0.5
PHYS 1002 [0.5]	Foundations of Physics II	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
PHYS 1008 [0.5]	Elementary University Physics II (see note below)	

3. 1.0 credit in:		1.0
PHYS 2604 [0.5]	Modern Physics I	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	

4. 2.0 credits from:		2.0
PHYS 2202 [0.5]	Wave Motion and Optics	

PHYS 2305 [0.5]	Electricity and Magnetism
PHYS 2401 [0.5]	Thermal Physics
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars
PHYS 3207 [0.5]	Topics in Biophysics
PHYS 3308 [0.5]	Electromagnetism
PHYS 3606 [0.5]	Modern Physics II
PHYS 3802 [0.5]	Advanced Dynamics
PHYS 3807 [0.5]	Mathematical Physics I
PHYS at the 4000-level	

Total Credits	4.0

Note: PHYS 1007, PHYS 1008 are acceptable only if a grade point average of at least 7.0 is presented on these courses.

Physics (PHYS) Courses

Physics

Faculty of Science

Note: Please consult with the Physics Department for advice on which first year course to take.

PHYS 1001 [0.5 credit]
Foundations of Physics I
This calculus-based course on classical mechanics covers kinematics, dynamics, gravitation, and oscillatory motion. This is a specialist course for students intending to take further courses in Physics.
Precludes additional credit for PHYS 1003 and PHYS 1007.
Prerequisite(s): Grade 12 Mathematics: Advanced Functions and Grade 12 Mathematics: Calculus and Vectors or equivalent, plus one of MATH 1004 or MATH 1002 (the MATH course may be taken concurrently); or permission of the Physics Department. Grade 12 Physics is strongly recommended. .
Lectures three hours a week, laboratory or tutorial three hours a week.

PHYS 1002 [0.5 credit]
Foundations of Physics II
An introduction to electricity, magnetism, electromagnetic fields, and wave motion. This is a specialist course for students intending to take further courses in physics.
Precludes additional credit for PHYS 1004 and PHYS 1008.
Prerequisite(s): PHYS 1001, or PHYS 1003, or PHYS 1007 with a grade of B-; MATH 1004 or MATH 1002 (may be taken concurrently); or permission of the Department.
Lectures three hours a week, laboratory or tutorial three hours a week.

PHYS 1003 [0.5 credit]
Introductory Mechanics and Thermodynamics
Mechanics, gravitation, oscillations, and thermodynamics. The application of calculus to solve problems in these areas of physics is introduced. This course is intended for students in the physical sciences and engineering. The laboratory is an essential and autonomous part of the course.
Precludes additional credit for PHYS 1001 and PHYS 1007.
Prerequisite(s): Grade 12 Physics or equivalent, plus Grade 12 Mathematics: Advanced Functions or equivalent, plus one of MATH 1004 or MATH 1002 (the MATH course may be taken concurrently). Note that Grade 12 Mathematics: Calculus and Vectors is strongly recommended. .
Lectures three hours a week, laboratory or tutorial three hours a week.

PHYS 1004 [0.5 credit]
Introductory Electromagnetism and Wave Motion
This calculus-based course introduces electricity, magnetism, oscillations, waves and optics. The laboratory is an essential and autonomous part of the course.
Precludes additional credit for PHYS 1002 and PHYS 1008.
Prerequisite(s): MATH 1004, ECOR 1101 (may be taken concurrently) or PHYS 1001 or PHYS 1003 or PHYS 1007 (a grade of at least B- is required for PHYS 1007), or permission of the Department.
Lectures three hours a week, laboratory or tutorial three hours a week.

PHYS 1007 [0.5 credit]
Elementary University Physics I
Mechanics, properties of matter, thermodynamics. Applications chosen in part from the life sciences. For students who lack the prerequisites for PHYS 1001 or PHYS 1003, or who do not intend to take upper-year courses in Physics.
Precludes additional credit for PHYS 1001 and PHYS 1003 and BIT 1002.
Prerequisite(s): (i) Grade 12 Mathematics: Advanced Functions or equivalent, or MATH 0107 (may be taken concurrently); or (ii) Grade 12 Mathematics: Calculus and Vectors or equivalent, or MATH 1007 (may be taken concurrently; or (iii) permission of the Physics Department.
Lectures three hours a week, laboratory or tutorial three hours per week.

PHYS 1008 [0.5 credit]
Elementary University Physics II
Electricity and magnetism, DC and AC circuits, wave motion and light. Elements of modern physics. Applications chosen in part from the life sciences.
Precludes additional credit for PHYS 1002 and PHYS 1004 and BIT 1003.
Prerequisite(s): PHYS 1001 or PHYS 1003 or PHYS 1007.
Lectures three hours a week, laboratory or tutorial three hours per week.

PHYS 1901 [0.5 credit]
Planetary Astronomy

Description of the known stellar, galactic and extra-galactic systems together with the instruments used to study them. Modern ideas concerning the structure, origin and evolution of our own planet. Formation of the Moon - Earth system. Study of the planets in our solar system. A 14" telescope is available for student use.
Note: Science students may only take this course as a free elective.
Precludes additional credit for PHYS 2203.
Lectures two and one-half hours a week.

PHYS 1902 [0.5 credit]
From our Star to the Cosmos

Starting with the Sun, the course studies its composition and source of power, then compares our Sun with the other stars in the galaxy and beyond. Modern ideas concerning the structure, origin and evolution of the universe, pulsars and supernovae are examined. A 14-inch telescope is available for student use.
Note: Science students may only take this course as a free elective.
Precludes additional credit for PHYS 2203.
Lectures two and one-half hours a week.

PHYS 1905 [0.5 credit]
How Things Work: Physics in Everyday Life

Intended for students with little or no background in Science. Examination of the physics behind everyday objects to learn about the basis for our modern technological world. Topics may include cell phones, microwave ovens, sustainable energy, weather, dance, music, hockey, and skiing.
Faculty of Science students may only take this course as a free elective.
Lectures three hours a week.

PHYS 2004 [0.5 credit]
Modern Physics for Engineers

Introduction to aspects of modern physics relevant to engineering. Thermal radiation. Concepts of relativistic kinematics. Wave-particle duality. Elements of quantum mechanics. Optical and x-ray spectra, lasers. Nuclear physics and applications. Condensed matter physics.
Precludes additional credit for PHYS 2604.
Prerequisite(s): PHYS 1002 or PHYS 1004 or PHYS 1008 with a grade of B- or better, plus MATH 1004 and MATH 1104 or equivalent. Restricted to B.Eng. students not in the Engineering Physics program. Students in programs other than B.Eng. must obtain permission of the Department.
Lectures three hours a week.

PHYS 2101 [0.5 credit]
Mechanics and Properties of Matter

Equations of motion for a single particle. Harmonic oscillation. Noninertial reference frames. Orbits in a central force field. Motion of systems of particles and of rigid bodies. Introduction to special relativity. Laboratory experiments in classical mechanics and properties of matter.
Prerequisite(s): PHYS 1001 and PHYS 1002, or PHYS 1003 and PHYS 1004, alternatively PHYS 1007 and PHYS 1008 with an overall average of B- or better; MATH 1004 and MATH 1104, or MATH 1002 and MATH 1102.
Lectures three hours a week, laboratory three hours a week, tutorials (optional) once a week.

PHYS 2202 [0.5 credit]
Wave Motion and Optics

Geometrical optics. Types of waves, vibrating string and the classical wave equation. General solutions for traveling waves. Superposition and interference, coherence, wave packets, waves in 2 and 3 dimensions. Propagation of electromagnetic waves. Light and physical optics, oscillator model for dispersion, diffraction, polarization, and refraction.
Prerequisite(s): PHYS 1001 and PHYS 1002, or PHYS 1003 and PHYS 1004 (PHYS 1007 and PHYS 1008 are also acceptable provided a minimum average grade of B- is presented); plus MATH 1004 and MATH 1104, or MATH 1002 and MATH 1102, and MATH 2004.
Lectures three hours a week.

PHYS 2203 [0.5 credit]
Astronomy

The observational basis of astronomy. The history of astronomy, properties of light, solar system observations and stellar astronomy.
Precludes additional credit for PHYS 1901 and PHYS 1902.
Prerequisite(s): PHYS 1002 or PHYS 1004 or permission of the department. PHYS 1008 with a grade of B- or better may also be used if MATH 1004 or MATH 1007 or MATH 1002 have been successfully completed.
Lectures three hours a week.

PHYS 2305 [0.5 credit]
Electricity and Magnetism

Electrostatic field and potential, Gauss' law. Properties of conductors. Magnetic effects from currents. Motion of charges in electric and magnetic fields. Energy in electric and magnetic fields. Electromagnetic induction. Maxwell's equations in vacuum using vector differential and integral calculus.
Prerequisite(s): PHYS 1001, PHYS 1002, or PHYS 1003 and PHYS 1004, alternatively PHYS 1007 and PHYS 1008 with an overall grade of B- or higher; MATH 2004.
Lectures three hours a week.

PHYS 2306 [0.5 credit]
Physics of Electrical and Electronic Measurements I
D.C. and A.C. circuit theory. Resonant circuits. Basic measuring devices, the oscilloscope; impedances, bandwidth, noise; vacuum tubes, transistors, useful approximations for circuit design; feedback, amplifiers, oscillators; operational circuits; digital circuits. Lectures emphasize the physical basis of instrument design. Laboratory emphasizes modern digital instrumentation.
Prerequisite(s): PHYS 1001, PHYS 1002 or PHYS 1003 and PHYS 1004, alternatively PHYS 1007 and PHYS 1008 with an overall grade of B- or better.
Lectures three hours a week, laboratory three hours a week.

PHYS 2401 [0.5 credit]
Thermal Physics
Introduction to thermodynamics and statistical mechanics. Temperature and thermodynamic equilibrium. Work, internal energy and heat; first law. Kinetic theory of gases. Basic probability theory. Microscopic states and entropy. Absolute temperature, reversibility and the second law of thermodynamics. Thermodynamic processes and applications.
Prerequisite(s): PHYS 1001 and PHYS 1002, or PHYS 1003 and PHYS 1004, (PHYS 1007 and PHYS 1008 are also acceptable provided a minimum average grade of B-) ; plus MATH 1004 and MATH 1104 or MATH 1002 and MATH 1102 .
Lectures three hours a week.

PHYS 2604 [0.5 credit]
Modern Physics I
The course is designed to provide a logical transition from classical to modern physics. Special relativity. Rutherford scattering, atomic models. Thermal radiation. Photoelectric effect, Compton scattering. Bohr theory of the hydrogen atom. Atomic energy states, optical spectra, lasers. X-rays. Radioactivity. Quantum Mechanics.
Precludes additional credit for PHYS 2004.
Prerequisite(s): PHYS 1001 and PHYS 1002, or PHYS 1003 and PHYS 1004 (PHYS 1007 and PHYS 1008 are also acceptable provided a minimum average grade of B- is presented); plus MATH 1004 and MATH 1104, or MATH 1002 and MATH 1102.
Lectures three hours a week, laboratory three hours a week.

PHYS 2903 [0.5 credit]
Physics and the Imagination
Physics has had a profound influence on music, philosophy, literature, film, and art. This is examined in a conceptual, non-technical, manner. A selection of topics will be studied.
Note: Faculty of Science students may only take this course as a free elective.
Prerequisite(s): second-year standing.
Lectures and discussion groups three hours a week.

PHYS 3007 [0.5 credit]
Third Year Physics Laboratory: Selected Experiments and Seminars
Students complete a small number of experiments selected from modern optics, holography, atomic physics, nuclear spectroscopy, radiation, etc. An exercise on literature searches and student seminars on experimental and numerical methods are included.
Prerequisite(s): PHYS 2202 and PHYS 2604, or permission of the Department.
Six hours a week.

PHYS 3008 [0.5 credit]
Third Year Physics Laboratory: Selected Experiments and Workshop
Students complete a small number of experiments selected from modern optics, holography, atomic physics, nuclear spectroscopy, radiation, etc. Instruction on instrumentation building techniques will be given.
Prerequisite(s): PHYS 2202 and PHYS 2604, or permission of the department.
Six hours a week.

PHYS 3207 [0.5 credit]
Topics in Biophysics
An introduction is made to biophysics. Topics in biology: animal movement, food irradiation, DNA damage and repair following irradiation, quantum tunneling in enzyme kinetics. Applications of physics in medicine: radiobiology, cancer treatment, and medical imaging.
Prerequisite(s): PHYS 2604 or permission of the Department.
Lectures three hours a week, tutorial or seminar one hour a week.

PHYS 3308 [0.5 credit]
Electromagnetism
Electrostatics feld and magnetostatics in the presence of matter. Solving Laplace's and Poisson's equations. Multipole expansions. Vector potential. Faraday's laws of induction; Maxwell's equations in matter. Waves in vacuum and dielectric media, guided waves.
Precludes additional credit for ELEC 3909.
Prerequisite(s): PHYS 2202, PHYS 2604, PHYS 2305, MATH 2004 or MATH 2008, and MATH 3705, or permission of the Department.
Lectures three hours a week.

PHYS 3402 [0.5 credit]
Heat and Thermodynamics
Zeroth, First, Second and Third Laws of Thermodynamics; enthalpy, Helmholtz and Gibbs functions and the Maxwell relations; phase transitions; thermodynamics of magnetism; cryogenics cooling by Joule-Thompson effect, adiabatic expansion of a gas, adiabatic demagnetization, helium dilution refrigeration; black body radiation; negative temperatures.
Prerequisite(s): PHYS 2101 and PHYS 2305, MATH 2007, MATH 2008, MATH 2107 and MATH 2401 or permission of the Department.
Lectures three hours a week.

PHYS 3606 [0.5 credit]
Modern Physics II
Elements of condensed matter physics, semiconductors, superconductivity. Elements of nuclear physics, fission, fusion, power generation. Introduction to particle physics. Ionizing radiation: production, interactions, detection. Medical physics: radiation biophysics, cancer therapy, imaging.
Also offered, with different requirements, as PHYS 3608 for which additional credit is precluded.
Prerequisite(s): PHYS 2604 and PHYS 3701, or permission of the Department.
Lectures three hours a week, laboratory two hours a week.

PHYS 3608 [0.5 credit]
Modern Applied Physics
Elements of condensed matter physics, semiconductors, superconductivity. Modern optics. Elements of nuclear physics, fission, fusion, power generation. Ionizing radiation: production, interactions, detection. Medical physics: radiation biophysics, cancer therapy, imaging.
Also offered, with different requirements, as PHYS 3606 for which additional credit is precluded.
Prerequisite(s): PHYS 2604 and PHYS 3701, or permission of the Department.
Lectures three hours a week, laboratory three hours a week.

PHYS 3701 [0.5 credit]
Elements of Quantum Mechanics
Analysis of interference experiments with waves and particles; fundamental concepts of quantum mechanics, Schrödinger equation; angular momentum, atomic beams; hydrogen atom; atomic and molecular spectroscopy; Pauli principle; simple applications in the physics of elementary particles.
Prerequisite(s): PHYS 2604, MATH 2000 [1.0] (may be taken concurrently), or MATH 2004 or MATH 2008, and MATH 3705 (may be taken concurrently), or permission of the Department.
Lectures three hours a week.

PHYS 3801 [0.5 credit]
Classical Mechanics
Introduction to Lagrangian and Hamiltonian mechanics: Poisson brackets, tensors and dyadics; rigid body rotations: introductory fluid mechanics coupled systems and normal coordinates; relativistic dynamics.
Prerequisite(s): PHYS 2101, PHYS 2202, PHYS 2305, MATH 2007, MATH 2008, MATH 2107, MATH 2401 or permission of the Department.
Lectures three hours a week.

PHYS 3802 [0.5 credit]
Advanced Dynamics
Equations of motion for a single particle. Oscillatory Motion. Lagrangian and Hamiltonian formulations of mechanics. Central force motion. Motion of systems of particles and of rigid bodies.
Prerequisite(s): PHYS 2202, PHYS 2604, and MATH 2004, or permission of the Department.
Lectures three hours a week.

PHYS 3807 [0.5 credit]
Mathematical Physics I
Boundary Value problems involving curvilinear coordinates; spherical harmonics, Bessel functions, Green's functions. Functions of a complex variable: analytic functions, contour integration, residue calculus.
Precludes additional credit for MATH 3007 or MATH 3057.
Prerequisite(s): PHYS 2202, MATH 2004, MATH 3705 or permission of the Department.
Lectures three hours a week, tutorial one hour a week.

PHYS 3808 [0.5 credit]
Mathematical Physics II
Solution of second-order total differential equations by Frobenius' method. Sturm-Liouville theory. Special functions: Legendre, Bessel. Hermite, Laguerre and associated functions. Partial differential equations: method of separation of variables, eigenfunctions and eigenvalues and eigenfunction expansions. Green's function techniques for solving inhomogeneous partial differential equations.
Precludes additional credit for MATH 3004, MATH 3008, MATH 3705, and PHYS 3806.
Prerequisite(s): PHYS 3807 or MATH 3007 or permission of the Department.
Lectures three hours a week.

PHYS 3999 [0.0 credit]
Co-operative Work Term Report
Provides practical experience for students enrolled in the Co-operative option. Students must receive satisfactory evaluations from their work term employer. Written and oral reports will be required. Graded as Sat or Uns.
Prerequisite(s): registration in the Physics Co-operative education option and permission of the Department. .
Four-month work term.

PHYS 4007 [0.5 credit]
Fourth-Year Physics Laboratory: Selected Experiments and Seminars
Students complete a small number of experiments selected from modern optics, holography, atomic physics, nuclear spectroscopy, radiation, etc. An exercise on literature searches and student seminars on experimental and numerical methods are included.
Prerequisite(s): PHYS 3606 (or PHYS 3608) and registration in the Engineering Physics program.
Laboratory, six hours a week.

PHYS 4008 [0.5 credit]
Fourth-Year Physics Laboratory: Selected Experiments and Workshop
Students complete a small number of experiments selected from modern optics, holography, atomic physics, nuclear spectroscopy, radiation, etc. Instruction on instrumentation building techniques will be given.
Prerequisite(s): PHYS 3007.
Six hours a week.

PHYS 4201 [0.5 credit]
Astrophysics
Stellar evolution, including stellar modeling, main sequence stars, red giants and the end states of stars such as neutron stars and black holes. Neutrino astrophysics.
Prerequisite(s): PHYS 3701, PHYS 3606 or PHYS 3608 and PHYS 4409, or permission of the Department. (PHYS 3606 or PHYS 3608 and PHYS 4409 may be taken concurrently).
Lectures three hours a week.

PHYS 4202 [0.5 credit]
Cosmology
Observational evidence for the Big Bang. Introduction to general relativity, expansion dynamics and contents of the universe. Physical processes in the expanding universe, inflation, nucleosynthesis, the cosmic microwave background, dark matter, and dark energy.
Prerequisite(s): PHYS 3701, PHYS 3606 or 3608 and PHYS 4409, or permission of the Department. (PHYS 3606 or PHYS 3608 and PHYS 4409 may be taken concurrently.).
Lectures three hours per week.

PHYS 4203 [0.5 credit]
Physical Applications of Fourier Analysis
Fourier transform, convolution. Sampling theorem. Applications to imaging: descriptors of spatial resolution, filtering. Correlation, noise power. Discrete Fourier transform, FFT. Filtering of noisy signals. Image reconstruction in computed tomography and magnetic resonance. Laplace transform. Integral transforms, application to boundary value problems.
Prerequisite(s): MATH 3705, or permission of the Department.
Lectures three hours a week.

PHYS 4208 [0.5 credit]
Modern Optics
Electromagnetic wave propagation; reflection, refraction; Gaussian beams and guided waves. Laser theory: stimulated emission, cavity optics, modes, gain and bandwidth; atomic and molecular lasers. Mode locking, Q switching. Diffraction theory, coherence, Fourier optics, holography, laser applications. Optical communication systems, nonlinear effects: devices, fibre sensors, integrated optics.
Prerequisite(s): PHYS 2202, PHYS 3606 (or PHYS 3608), and PHYS 3308 or permission of the Department.
Also offered at the graduate level, with different requirements, as PHYS 5318, for which additional credit is precluded.
Lectures three hours a week.

PHYS 4307 [0.5 credit]
Electromagnetic Radiation
Electromagnetic wave propagation in a vacuum, dielectrics, conductors, and ionized gases, reflection, refraction, polarization at the plane boundary between two media; waveguide and transmission line propagation; dipole and quadrupole radiation fields; antenna systems. Electromagnetic mass, radiation pressure. Tensor notation, transformation of the electromagnetic fields.
Prerequisite(s): PHYS 3308, PHYS 3801, PHYS 3807 and PHYS 3808 (except for Mathematics and Physics Double Honours students), or permission of the Department.
Lectures three hours a week.

PHYS 4407 [0.5 credit]
Statistical Physics
Equilibrium statistical mechanics and its relation to thermodynamics. Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics are derived, and applied in appropriate physical situations. Fluctuations. Kinetics and transport processes, including the Boltzmann transport equation and some of its applications.
Prerequisite(s): PHYS 3402, PHYS 2602 or PHYS 3601, PHYS 3701 or PHYS 3602, PHYS 4707 (may be taken concurrently); or permission of the Department.
Lectures three hours a week.

PHYS 4409 [0.5 credit]
Thermodynamics and Statistical Physics
The three Laws of Thermodynamics, enthalpy, Helmholtz and Gibbs functions. Equilibrium statistical mechanics and its relation to thermodynamics. Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.
Precludes additional credit for PHYS 3402 and PHYS 4407.
Prerequisite(s): PHYS 3701 (may be taken concurrently), MATH 2004 and MATH 3705, or permission of the Department.

PHYS 4508 [0.5 credit]
Solid State Physics
An introduction to solid state physics. Topics include crystal structure, phonons and lattice vibrations, conductors, semiconductors, insulators and superconductivity.
Prerequisite(s): PHYS 3606 or PHYS 3608, and PHYS 3701, or permission of the Department.
Lectures three hours a week.

PHYS 4602 [0.5 credit]
Particle Physics
Properties of leptons, quarks and hadrons. The fundamental interactions, conservation laws, invariance principles and quantum numbers. Resonances in hadron-hadron interactions. Three body phase space. Dalitz plots. Quark model of hadrons, mass formulae. Weak interactions, parity violation, decay of neutral kaons, CP violation, Cabibbo theory.
Prerequisite(s): PHYS 4707 or permission of the Department.
Also offered at the graduate level, with different requirements, as PHYS 5602, for which additional credit is precluded.
Lectures three hours a week.

PHYS 4608 [0.5 credit]
Nuclear Physics
Ground state properties of nuclei. Nuclear models, binding energy, properties of excited nuclei. Alpha, beta and gamma decay. Passage of radiation through matter, detectors. Nuclear reactions, cross sections, fission, fusion. Elements of neutron physics.
Prerequisite(s): PHYS 3606 or PHYS 3608 or permission of the Department.
Lectures three hours a week.

PHYS 4707 [0.5 credit]
Introduction to Quantum Mechanics I
The basic interpretative postulates of quantum mechanics; applications of wave mechanics and operator methods to various quantum mechanical systems; quantum mechanical treatment of angular momentum.
Prerequisite(s): PHYS 3701 and PHYS 3807 or equivalent, or permission of the Department.
Lectures three hours a week.

PHYS 4708 [0.5 credit]
Introduction to Quantum Mechanics II
Scattering theory and application; bound state problems; approximation methods.
Prerequisite(s): PHYS 4707 or permission of the Department.
Lectures three hours a week.

PHYS 4807 [0.5 credit]
Computational Physics
Computational methods used in analysis of experimental data. Introduction to probability and random variables. Monte Carlo methods for simulation of random processes. Statistical methods for parameter estimation and hypothesis tests. Confidence intervals. Multivariate data classification. Unfolding methods. Examples primarily from particle and medical physics.
Prerequisite(s): third year standing in a physics program and an ability to program in FORTRAN, Java, C or C++, and permission of the Department.
Also offered at the graduate level, with different requirements, as PHYS 5002, for which additional credit is precluded.
Lectures three hours a week.

PHYS 4901 [0.5 credit]
Special Topics in Physics
Each year, at the direction of the Department, a course on a special topic may be offered.
Prerequisite(s): permission of the Department.

PHYS 4907 [0.5 credit]
Fourth-Year Project
Same as PHYS 4909 except that it extends over the fall term only. (See PHYS 4909 for details.).
Prerequisite(s): permission of the Department.
A minimum of six hours laboratory or private study a week.

PHYS 4908 [0.5 credit]
Fourth-Year Project
Same as PHYS 4909 except that it extends over the winter term only. (See PHYS 4909 for details.).
Prerequisite(s): permission of the Department.
A minimum of six hours laboratory or private study a week.

PHYS 4909 [1.0 credit]
Fourth-Year Project
These are advanced projects of an experimental or theoretical nature with an orientation towards research. A written progress report, by mid-term for PHYS 4907, PHYS 4908, and by mid-year for PHYS 4909, must be submitted to the student's supervisor prior to the last day for withdrawal from the course. A written and an oral report are required at the conclusion of the project.
Prerequisite(s): permission of the Department.
A minimum of six hours laboratory or private study a week.

Summer session: some of the courses listed in this Calendar are offered during the summer. Hours and scheduling for summer session courses will differ significantly from those reported in the fall/winter Calendar. To determine the scheduling and hours for summer session classes, consult the class schedule at central.carleton.ca

Not all courses listed are offered in a given year. For an up-to-date statement of course offerings for the current session and to determine the term of offering, consult the class schedule at central.carleton.ca