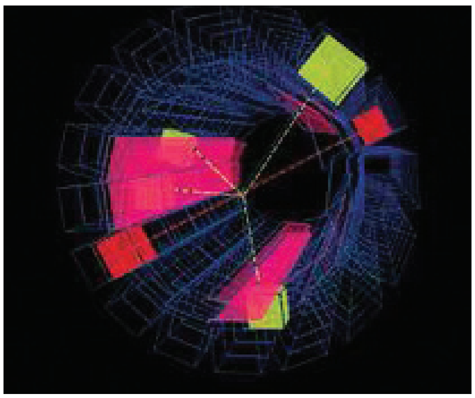
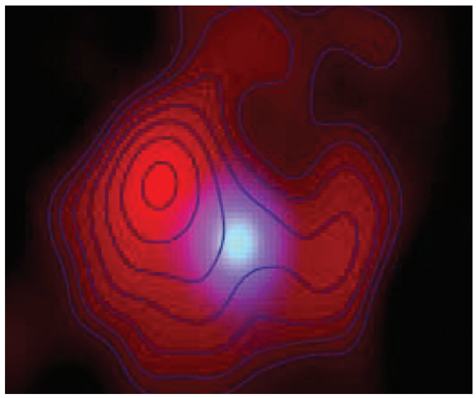
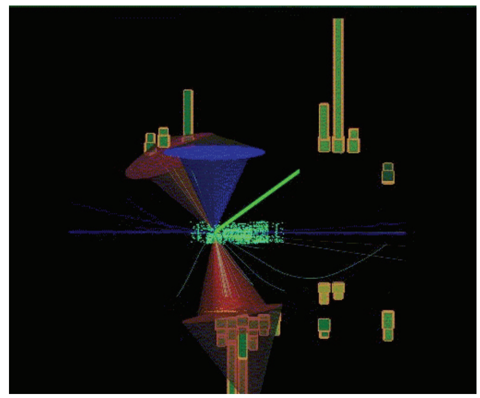
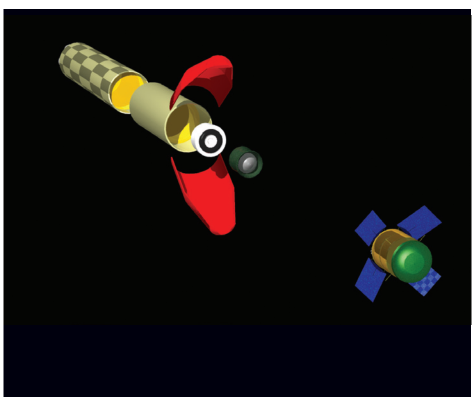
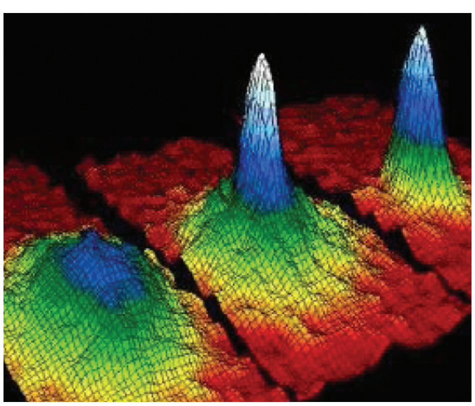
PHYSICS & ASTRONOMY

UNDERGRADUATE HANDBOOK 2013-2014

www.physics.yorku.ca

science

YORK UNIVERSITÉ UNIVERSITY

WELCOME TO PHYSICS & ASTRONOMY 2013-2014

Welcome to the Department of Physics and Astronomy at York University. We are honoured that you have chosen to entrust us with your university education.

I want your experience with us to be both stimulating and productive. This Handbook and our website (www.physics.yorku.ca) will help to guide your way. Those students interested in engineering should refer to the mini-calendar or webpage www.eng.yorku.ca for the School of Engineering. We are committed to teaching of the highest quality. You will find that this process is enriched by our vigourous research activity, which occurs in a dazzling array of fields.

Faculty members in the Department are engaged in a wide variety of research activities for which they are internationally renowned. Our astronomers are active at the world's major observing facilities, including those in Hawaii and Chile, and also make use of a wide variety of space telescopes including the Hubble Space Telescope, Gravity Probe B, the Far-Ultraviolet Spectroscopic Explorer, and the Space Infrared Telescope Facility (Spitzer.) Our high energy physics group is privileged to perform experiments at particle accelerators in Switzerland, Japan, and the United States, and is supported by a strong departmental theory group. Our atomic and laser physicists have been involved in producing and studying antihydrogen, atom trapping, and creating Canada's first Bose-Einstein condensate (a new form of matter.) Space scientists are designing elevators to space and plotting a course to Mars and beyond.

Physics and Astronomy students have access to well-equipped laboratories throughout their undergraduate career. For example, a state-of-the-art laser physics laboratory serves students in third year. Astronomy students are given access to the telescopes of the York Observatories starting in first year.

As part of their university experience, our students also enjoy diverse opportunities for enrichment outside of the classroom. Besides the Physics Society, Astronomy Club, and Biophysics Club, these include events sponsored by Norman Bethune College, the natural campus home to science students at York.

Please don't hesitate to contact me for information about specific departmental affairs or to arrange for an appointment. I can be reached by phone at 416-736-5249 or by email to chphas@yorku.ca.

Professor Marshall McCall, Chair

Physics and Astronomy 128 Petrie Science & Engineering Building Hours: 10:00 am – 5:00 pm (closed Noon – 1:00 pm) Tel: 416-736-5249 phas@yorku.ca Dr. M. McCall, Chair M. Caplan, Administrative Assistant and Assistant to the Director, Graduate Program L. O'Brien, Undergraduate Program Secretary **Earth & Space Science & Engineering** 102 Petrie Science & Engineering Building 416-736-5245 esse@yorku.ca Dr. R. Lee, Chair **Lassonde School of Engineering** 1012L Lassonde Building 416-650-8215 eng@.yorku.ca Dr. R. Hornsey, Associate Dean	**Emergency/Security Numbers** Emergencies – on-campus (Ambulance, Fire, Police) ext. 33333 (or 911) Security Control Centre Ext. 58000 York goSAFE Program (Student Security Escort Service) 416-736-5454

Important Notice

This Handbook is meant as a supplement to the official York University Calendar (available at www.yorku.ca). It describes in detail the options for studying physics and astronomy at York, and contains detailed course descriptions. The Department reserves the right to make changes to the information contained in the Handbook without prior notice.

Students are responsible for familiarizing themselves with the specific requirements of the degree they seek.

Not every course listed in the Handbook will necessarily be offered in any academic year. York reserves the right to limit the number of students who enroll in any program or course. While reasonable efforts will be made to offer courses and classes as required within programs, admission to a program does not guarantee admission to any given class or course.

If there is inconsistency between the general academic regulations and policies published in the Handbook and such regulations and policies as established by resolution of a Faculty or of the University Senate, the version of such material as it is established by the Faculty or the University Senate will prevail.

Front Cover Photo Credits

Top row, left: Antihydrogen is detected by its annihilation products. Photo by Athena Collaboration.

Top row, centre: A radio image made using a global array of radio telescopes, which shows a possible black hole or neutron star in the centre of supernova 1986J. Image by M. Bietenholz and N. Bartel.

Top row, right: The production of a Higgs boson, observed via its decay to two b quarks and accompanying W boson, in a simulated proton-antiproton collision event in the DZero detector. Image by DZero Collaboration.

Centre left: The space element and staging design of Northern Light, a Canadian mission to Mars, York University and Thoth Technology Inc. Photo by Thoth Technology Inc.

Lower left: Transition of a thermal atom cloud to Bose Einstein Condensate as the temperature is lowered below 100 nanokelvin. Photo by W. van Wijngaarden.

Note: All general information and course references have been checked for accuracy, but there may be inconsistencies or errors. If you become aware of any, please bring these to the attention of the Department of Physics and Astronomy.

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SUMMARY OF SUPPORT SERVICES

Office or Contact	Primary Service
Bethune College Academic Advisor 416-736-2100 ext. 33940 nbcadadv@yorku.ca	General advising; study skills; college activities; upcoming events
Bethune Writing Centre 205 Bethune College 416-736-5164 http://bethune.yorku.ca/writing	Improving writing skills
Career Centre 202 McLaughlin College 416-736-5351 www.yorku.ca/careers career@yorku.ca	Career counselling; Learning skills development workshops; Virtual resources; Internships
Centre for Student Community & Leadership Development (SC&LD) S172 Ross Building 416- 736-5144 www.yorku.ca/scld	Enrich student life by promoting education, awareness and growth; celebrating diversity, encouraging collaboration and developing citizenship.
Counselling & Disability Services N110 Bennett Centre for Students Service 416-736-5297 www.yorku.ca/cds	Personal counselors, crisis counseling, group development workshops, learning skills training, and support for learning disabilities and psychiatric disabilities
Faculty and Staff	Advice on courses and careers
Centre for Human Rights S327 Ross Building 416-736-5682 www.yorku.ca/rights rights@yorku.ca	Assists individuals and groups to address and resolve allegations of discrimination and harassment as defined by the Ontario Human Rights Code (Code).
Office of the Ombudsperson 1050 York Research Tower www.yorku.ca/ombuds ombuds@yorku.ca	Provides an impartial and confidential service to assist current members of York University who have been unable to resolve their concerns about University authorities' application of York University policies, procedures and/or practices.

Office of the Registrar Bennett Centre for Student Services 416-736-YORK www.registrar.yorku.ca	Enrolment procedures; Sessional dates and refund table; Petitions, permission to take a course at another university, transcripts, and most forms
Science Academic Services 352 Lumbers Building 416-736-5085 sciquest@yorku.ca	Faculty policies and procedures; General advising, course selection/changes. Counter hours: 10:00 am – 4:00 pm Telephone hours: 8:30 am – 4:30 pm
Sexual Assault Survivor's Support Line B449 Student Centre 416-736-2100 x 40345 http://www.yorku.ca/sassl/	Provide unbiased and non-judgmental peer support and referrals to survivors of sexual violence; Educational workshops
Student Financial Services N201 Bennett Centre for Student Services 416-872-YORK http://sfs.yorku.ca	Scholarships, financial problems, OSAP information
YFS Health Plan 336 Student Centre 416-736-5324 www.yfs.ca healthplan@yorku.ca	Health plan sponsored by York Federation of Students

TIMETABLE

FALL/WINTER 2013 – 2014

COURSE	TITLE	DAY	TIME	ROOM	INSTRUCTOR
PHYS 1010 6.0 A Y	Physics	MWF	12:30 – 13:30	CLH I	R. Koniuk
	Tutorial	R	13:30 – 14:30	VH A	
PHYS 1070 3.0 A F	Fundamentals of Astronomy	TR	11:30 – 13:00	SC 302	M. De Robertis
	Tutorial	W	14:30 – 15:30	SC 302	
PHYS 1410 6.0 A Y	Physical Science	MWF	13:30 – 14:30	LAS B	A. Terekidi
	Tutorial	T	13:30 – 14:30	CLH D	
PHYS 1420 6.0 A Y	Physics with Applications to Life Sciences	MWF	12:30 – 13:30	CLH I	A. Matvienko/ S. Jerzak
	Tutorial	T	13:30 – 14:30	VH A	

For PHYS 1010, PHYS 1410, PHYS 1420, and PHYS 1510 lab times, check the York University Lecture Schedule.

COURSE	TITLE	DAY	TIME	ROOM	INSTRUCTOR
PHYS 1470 3.0 N W	Highlights of Astronomy	TR	11:30 – 13:00	ACE 011	N. Bartel
	Tutorial	W	14:30 – 15:30	SLH B	
PHYS 1510 4.0 A F	Introduction to Physics	TR	16:00 – 17:30	LAS C	C. Storry
PHYS 2010 3.0 M W	Classical Mechanics	WF	9:00 – 10:30	SC 303	A. Kumarakrishnan
	Tutorial	M	13:30 – 14:30	SC 303	
PHYS 2020 3.0 A F	Electricity & Magnetism	MWF	12:30 – 13:30	LSB 106	S. Menary
	Tutorial	W	9:30-10:30	CLH H	
PHYS 2030 3.0 A F	Computational Methods for Physicists & Engineers	T R	9:30 – 11:30 10:30 – 11:30	ACW 203	A. Matvienko
PHYS 2040 3.0 A F	Relativity & Modern Physics	MWF	13:30 – 14:30	PSE 321	S. Menary
	Tutorial	M	14:30 – 15:30	PSE 321	
PHYS 2060 3.0 M W	Optics & Spectra	TR	10:00 – 11:30	SC 303	C. Storry
	Tutorial	W	12:30 – 13:30	SC 303	
PHYS 2070 3.0 M W	Galaxies & the Universe	TR	13:00 – 14:30	SC 302	M. McCall
PHYS 2211 1.0 A F	Experimental Electromagnetism	T,R or F or W or R	14:30 – 17:30 15:30 – 18:30 11:30 – 14:30	PSE 210 PSE 210 PSE 210	C. Storry
PHYS 2212 1.0 M W	Experimental Physics	T or R or R	14:30 – 17:30 11:30 – 14:30	PSE 220 PSE 220	C. Storry
PHYS 2213 3.0 A Y	Experimental Physics with Data Analysis	M	9:30 – 10:30	SC 218	C. Storry
	Lab	T,R or F or W or R	14:30 – 17:30 15:30 – 18:30 11:30 – 2:30	PSE 210 PSE 210 PSE 210	

COURSE	TITLE	DAY	TIME	ROOM	INSTRUCTOR
PHYS 3010 3.0 M W	Classical Mechanics	MWF	11:30 – 12:30	PSE 321	W. van Wijngaarden
PHYS 3020 3.0 A F	Electromagnetics I	MWF	11:30 – 12:30	PSE 321	W. Taylor
PHYS 3030 3.0 A F	Statistical & Thermal Physics	TR	13:00 – 14:30	PSE 321	A. Terekidi
PHYS 3040 6.0 A Y	Modern Physics	MWF	10:30 – 11:30	BC 322	R. Lewis
	Tutorial	W	13:30 – 14:30	BC 322	
PHYS 3050 3.0 A F	Electronics I	TR	11:30 – 13:00	PSE 321	J. Shan
	Lab	T or R	16:00 – 19:00 15:30 – 18:30	PSE 120 PSE 120	
PHYS 3070 3.0 A F	Planets & Planetary Systems	T R	13:00 – 14:30 13:00 – 14:30	SC 219 SC 219	J. Moores
PHYS 3080 3.0 A F	Atmospheric Radiation & Thermodynamics	MWF	9:30 – 10:30	PSE 321	J. Whiteway
PHYS 3090 3.0 A F	Methods in Theoretical Physics	MWF	9:30 – 10:30	PSE 321	R. Koniuk
PHYS 3150 3.0 M W	Electronics II	TR	11:30 – 13:00	PSE 321	G. Vukovich
	Lab	T or R	15:30 – 18:30	PSE 120	
PHYS 3220 3.0 A F	Experiments in Modern Physics	R	14:30 – 15:30	CB 129	W. Taylor
	Lab	MTWRF	10:00 – 16:00 (3 hours, open)	PSE 126	
PHYS 3250 3.0 A F	Introduction to Space Communications	MWF	12:30 – 13:30	CB 120	N. Bartel
PHYS 3280 3.0 M W	Physics of the Space Environment	MWF	13:30 – 14:30	PSE 321	R. Jagpal
PHYS 3320 3.0 M W	Microsystems Technology	MW	11:30 – 13:00	SC 228	R. Lee
PHYS 3330 3.0 M W	Space Engineering Materials	WF	15:30 – 17:00	BC 225	TBA
PHYS 3901 0.0 A F	Physics Internship Work Term				By permission only
PHYS 3900 0.0 M W	Physics Internship Work Term				By permission only
PHYS 3900 0.0 A F	Astronomy Internship Work Term				By permission only
PHYS 4010 3.0 A F	Quantum Mechanics	MF W	12:30 – 13:30 10:30 – 11:30	BC 230 SC 220	A. Terekidi
PHYS 4011 3.0 M W	Atomic and Molecular Physics	MWF	15:30 – 16:30	BC 323	E. Hessels
PHYS 4020 3.0 M W	Electromagnetics II	MWF	9:30 – 10:30	BC 323	E. Hessels

COURSE	TITLE	DAY	TIME	ROOM	INSTRUCTOR
PHYS 4040 3.0 M W	Elementary Particle Physics	MWF	11:30 – 12:30	CB 122	R. Lewis
PHYS 4050 3.0 M W	Solid State Physics	MWF	10:30 – 11:30	BC 214	W. van Wijngaarden
PHYS 4060 3.0 A F	Time Series & Spectral Analysis	M W	14:00 – 15:30 14:30 – 16:00	SC 203	C. Haas
PHYS 4061 3.0 M W	Experimental Techniques in Laser Physics	F	12:30 – 13:30	BC 323	A. Kumarakrishnan
	Tutorial	F	13:30 – 14:30	BC 323	
	Lab 1	MT	14:30 – 17:30	PSE 226	
	Lab 2	WR	14:30 – 17:30	PSE 226	
PHYS 4062 3.0 A F	Atom Trapping	R	14:30 – 15:30	BC 228	A. Kumarakrishnan
	Tutorial	R	15:30 - 16:30	BC 228	
	Lab	WF	14:30 – 17:30	PSE 226	
PHYS 4070 3.0 M W	Stars and Nebulae	TR	10:00 – 11:30	CC 208	P. Hall
PHYS 4110 3.0 M W	Dynamics of Space Vehicles	TR	11:30 – 13:00	CB 120	J. Shan
PHYS 4120 3.0 A F	Gas and Fluid Dynamics	TR	11:30 – 13:00	CB 120	J. Moores
PHYS 4210 3.0 A F	Advanced Experimental Physics I	M	10:30 – 11:30	BC 228	M. George
	Lab	MTWRF	10:00 – 16:00 (6 hours, open)	PSE 123	
PHYS 4211 3.0 M W	Advanced Experimental Physics II	M	14:30 – 15:30	BC 225	M. George
	Lab	MTWRF	10:00 – 16:00 (6 hours, open)	PSE 123	
PHYS 4270 4.0 A Y	Astronomical Techniques		**NOT OFFERED**		
PHYS 4310 3.0 A F	Physics or Astronomy Project				By permission only
PHYS 4310 3.0 M W	Physics or Astronomy Project				By permission only
PHYS 4330 3.0 M W	Radio Science and Techniques for Space Exploration	MWF	12:30 – 13:30	SC 220	N. Bartel
PHYS 4350 6.0 A Y	Space Hardware	M	10:00 – 12:30	PSE 315	B. Quine
	Lab	M	14:30 – 19:30	PSE 315	
PHYS 4360 3.0 A F	Payload Design	TR	14:30 – 16:00	PSE 315	J. Shan
PHYS 4361 3.0 M W	Space Mission Design	MW	9:30 – 11:00	SC 223	M. Daly
PHYS 4410 3.0 M W	Space Geodynamics		**NOT OFFERED**		
PHYS 4550 3.0 A F	Control Systems	TR	10:00 – 11:30	PSE 315	G. Vukovich

COURSE	TITLE		DAY	TIME	ROOM	INSTRUCTOR
BPHS 2090 3.0 A F	Current Topics in Biophysics		TR	11:30 – 13:00	BC 202	S. Jerzak
BPHS 3090 3.0 M W	Biophysics I		MWF	9:30 – 10:30	BC 230	C. Bergevin
BPHS 3900 0.0 A F	Biophysics Internship Work Term					By Permission Only
BPHS 3900 0.0 M W	Biophysics Internship Work Term					By Permission Only
BPHS 4090 4.0 A F	Biophysics II		TR	10:00 – 11:30	BC 225	C. Bergevin
		Lab	W	13:00 – 16:00	PSE 108	

Building Codes

ACW	Accolade West
BC	Bethune College
CB	Chemistry Building
CC	Calumet College
CLH	Curtis Lecture Halls
LAS	Lassonde Building
PSE	Petrie Science & Engineering
SLH	Stedman Lecture Hall
SC	Stong College
VH	Vari Hall

INTRODUCTION

What are Physics and Astronomy?

Physics is the most fundamental science discipline. Physics can be thought of as providing the complete model of the natural world. Although the beauty of this model is valued, the model must be subject to experimental verification.

Physics is largely concerned with the investigation of systems where the number of variables is small. Areas concerned with extremely complex systems, like geophysics and atmospheric physics, have become disciplines in their own right. Astronomers focus upon the most complex systems of all, but use knowledge about fundamental physics in their attempts to understand them. In turn, astronomical research often leads to new insights into physics, such as the exciting connections between cosmology and elementary particle physics.

The ***subdisciplines of physics*** can be identified by the typical length scales which they probe.

The largest distance scales are studied in astronomy and astrophysics. In fact, astronomy covers a wide range of distances: in planetary astronomy, the astronomical unit (distance between Sun and Earth - 10^{11} m) is important, the light-year (about 10^{16} m) represents the distance scale of stellar astronomy, while the range of millions to billions of light-years (10^{22} m to 10^{25} m) is relevant for studies of the nearest galaxies to the largest superclusters and the universe as a whole.

Physics at distance scales of our everyday experience (e.g., meters) is the concern of classical physics, including classical and fluid mechanics, with modern developments in the area of nonlinear phenomena, such as chaos.

At the distance scale of nanometers (10^{-9} m) we are at the size of atoms. This region is dominated by the electric and magnetic forces of charged particles (electrons and protons), and falls into the realm of atomic, molecular, and optical physics. The term optical physics has been coined because of the important role played by lasers in probing atoms and molecules, and more recently macromolecules called atomic clusters (e.g., fullerenes or buckyballs - soccerball-shaped assemblies of 60 or more carbon atoms).

When very many atoms (10^{24}) are bound to form a solid or a crystal, simply as the net result of electrostatic forces, we observe new phenomena. Conduction in metals, non-conduction in crystals, semiconductor devices - these are technologically important processes governed by quantum physics and studied in condensed matter or solid-state physics. When dealing with large numbers of particles in the gaseous or fluid state, the field becomes classical and/or quantum statistical mechanics. A special case occurs at high temperatures when atoms ionize. This is the field of plasma physics.

At the femtometer or fermi scale (10^{-15} m) we are entering the realm of nuclear physics. Nuclear physics treats neutrons and protons as the fundamental building blocks of nuclei, and explains why light nuclei fuse (the energy production mechanism of stars, such as our Sun), and why one gains energy from the fission of heavy nuclei (such as in nuclear power plants). It explains why certain nuclei are stable, and why others are not, and why they decay radioactively by particle emission.

At the sub-fermi scale, we study the structure of protons, neutrons and other particles, and find that they are made of quarks. Particle physics (also called high-energy physics) is the most fundamental of the physics disciplines. Our present understanding is that quarks, electrons, and neutrinos are point-like objects that come in three families, and form the basis of most, but perhaps not all matter in the universe. Big particle accelerators can be used to create particles that normally do not occur in our every-day life, but which existed in the earliest stages of the universe after the Big Bang.

Why are Physics and Astronomy Useful?

Physics and astronomy are classical disciplines that are founded upon a powerful investigative technique known as the Scientific Method. Experiments are used to observe nature and explore phenomena. Theories are constructed to understand the phenomena. They lead to further probing by refined experiments. This methodology is being applied increasingly to disciplines that were less mathematical in the past, such as biology, and even economics. Studying physics or astronomy may be the best way to grasp this methodology.

The traditional view of a physicist is that of someone hovering over an apparatus on a bench, and the traditional view of an astronomer is that of someone looking through a telescope. This is not quite right, as most physicists and astronomers today are using computers to test their theories as well as to collect and analyze data from their experiments. Students make extensive use of computers and have excellent prospects of finding computer-related jobs. Physics and Astronomy students acquire sophisticated problem-solving skills, and at the same time obtain computer training, in reasonably small classes.

Why Study Physics and Astronomy at York?

Over the past 15 years York University has hired excellent young researchers in experimental as and theoretical physics, as well as astronomy/astrophysics. These researchers have built their careers while training graduate students and have joined senior colleagues in establishing sound curricula in physics and astronomy, with strong experimental components. We ensure that our students not only learn the subject matter, but that they also learn how to think critically about it and to apply it to analyze and solve problems. In the process, Physics and Astronomy studies provide an excellent opportunity to:

- Acquire substantial mathematical skills with emphasis on practical mathematics, as opposed to theorems and formal language.
- Acquire computing skills including programming, visualization of data, symbolic and numerical computation, and computer-interfacing of laboratory experiments.
- Acquire technical writing skills, particularly in the writing of scientific laboratory reports requiring a detailed analysis of the physics, the methodology of an experiment, and the description of results obtained.
- Acquire breadth both within and outside of physics and astronomy. To satisfy the general education requirement, students may choose amongst many options from offerings outside of the Faculty of Science and Engineering. The selection of eligible courses has been vastly expanded in recent years to fully accommodate different interests.

CAREERS

Students wanting to know where their studies might lead them should refer to our survey of alumni i.e. graduates from our programs who have established their careers. They survey can be found on our website.

Students interested in exploring the current job market should check our website www.physics.yorku.ca under Careers, where we update web links to over 100 companies that hire physicists, engineers and information technologists.

Students interested in physics/astronomy-related graduate careers should focus on the 4-year degree paths.

Students interested in becoming teachers - A B.Sc. is a possible route to a career in science education. In Ontario, an Honours degree opens up the opportunity to teach Grades 11 and 12. Students who acquire a Bachelors degree are eligible to teach Grades 1 through 10. To teach intermediate (Grades 9 and 10) or senior (Grades 11 and 12) levels, students must acquire a total of 36 credits in a first teaching subject and 24 credits in a second. Information about which courses in physics or astronomy can be counted towards a physics teachable is available from the Faculty of Education.

Students interested in becoming science teachers should seriously consider the B.Ed. Consecutive Program. Students are eligible to enter the B.Ed. Consecutive Program following completion of their undergraduate degree. Students acquire a B.Ed. after one more year of study beyond their B.Sc. Interested student should contact the Faculty of Education for further information.

B.SC. BACHELOR AND B.SC. HONOURS PATHS

Overview

There are many options for education, including combining studies in Physics and/or Astronomy with studies in other disciplines. Within the Department of Physics and Astronomy itself, students may choose among a variety of study paths. These paths are distinguished on the basis of course requirements. They are:

Physics Stream

The most flexible path for students wishing to become grounded in fundamental physics and its applications.

Applied Physics Stream

A more programmed path of physics study emphasizing applications.

Astronomy Stream

A path of study which provides grounding in astronomy and astrophysics on top of training in fundamental physics and its applications.

Space Science Stream

A path of study beginning in 3rd year which emphasizes training in fields relevant to the exploration of space beyond the immediate environment of the Earth. Normally, this is open to students who begin as Space Science majors in the Department of Earth, Space Science and Engineering.

Biophysics Program

This is a path of study which allows students to learn not only fundamentals of biology and physics, but also how to apply the laws and methods of physics to understand biological processes. Interested students should refer to the Biophysics Handbook for complete details.

Students should also be aware that the Department is integrally involved in the teaching of space engineering:

Space Engineering

This stream has considerable overlap with the Space Science stream, but includes courses in engineering design necessary to acquire certification as a professional engineer. See the School of Engineering's supplemental calendar for more information.

Degree Classifications

The classification of the degree received after following a particular path of study depends upon the number of credits taken, whether the path is followed in conjunction with studies in another discipline, and whether the path followed is a "stream" or a "program". Students involved with the Department of Physics and Astronomy will be granted one of the following degrees upon satisfaction of corresponding academic requirements:

1. 3-year (90 credits) B.Sc. in Physics and Astronomy (Physics Stream or Astronomy Stream)
2. 4-year (120 credits) Specialized Honours B.Sc. in Physics and Astronomy (Physics Stream, Applied Physics Stream, Astronomy Stream, or Space Science Stream)
3. 4-year (120 credits) B.Sc. in Biophysics.
4. 4-year (120 credits) Double-Major Honours B.Sc. in Physics and Astronomy (Physics Stream or Astronomy Stream) and in another discipline from the Faculty of Science and Engineering or other Faculties.
5. 4-year (120 credits) Major-Minor Honours B.Sc. in Physics and Astronomy (Physics Stream or Astronomy Stream) and in another discipline from the Faculty of Science and Engineering or other Faculties.
6. 4-year (120 credits) Honours B.Sc. in Physics and Astronomy (Physics stream or Astronomy Stream)
7. 4-year B.A.Sc. Honours (Computer Engineering, Geomatics Engineering or Space Engineering).

Which Path Should You Choose?

The path you choose is largely determined by personal preference and career ambitions. Career possibilities are described elsewhere in this handbook, and you are urged to explore the possibilities as early as possible. The department offers advising to all interested students, including high-school students who intend to apply at some point. Please make use of the contact information provided to schedule an appointment. The following remarks should serve as a guide.

By the second year of studies, you should seriously consider whether you intend to continue with a graduate career (in physics, astronomy, space science, engineering, or other related disciplines - or a professional school, such as medicine, dentistry, law or business), or whether the intent is to enter the job market upon graduation (possibly after further technical training). To be accepted to graduate studies, you typically need to obtain at least a B+ average over the last two years of study in an Honours-level program.

Switching between options is possible, in many instances without penalty with respect to the time required to complete the degree. Note that it is more difficult to switch in the final year(s).

Computational Physics and Computational Astronomy have emerged as important branches of physics over the last two decades. They are related to Theoretical Physics as well as to Applied Mathematics, and have produced many Ph.D. graduates who have moved on to revolutionize fields in chemistry, biology, financial mathematics, and others. At York, you have excellent opportunities to tap into the expertise of researchers in numerical and symbolic computing. This area is as important for those students who wish to pursue graduate careers as it is for those who wish to apply their scientific skills in the workplace immediately after graduation.

INTERNSHIPS

Students in the Physics and Astronomy Program now have an opportunity to engage in workplace internships for up to four semesters (16 months) following their third year of study. In combination with advice from the Program, the Career Centre of York University coordinates internships through its Technology Internship Program (TIP), providing students with training and support in seeking internship positions and also overseeing their administration. Employers are motivated to hire students in the internship program because involvement in experiential education entitles them to tax benefits. Each work term completed successfully is noted officially by an entry on the student's transcript. Eligible students must have an overall cumulative grade point average of at least 5.0 and must have at least 9 credits remaining to graduate. Students interested in participating in the internship program should identify themselves to the Physics and Astronomy Program and to TIP at least one semester before the semester in which they would like to begin working.

ENTRANCE REQUIREMENTS

To be eligible to major in Physics and Astronomy at York starting in first year, it is necessary to have passed Grade 12 courses or their equivalents in English, Physics, and Mathematics. Specifically, applicants from high schools in Ontario must have passed

- ENG4U - 12U English (York University requirement)
- SPH4U - 12U Physics
- MHF4U - 12U Advanced Functions
- MCV4U - 12U Calculus and Vectors

SCH4U - 12U Chemistry is recommended, but not required for admissions. Those students lacking Grade 12U Chemistry will be required to take an equivalent course at York prior to enrolling in University level chemistry courses.

Applicants admitted to York who lack any of the requirements cannot become majors until such time as the deficiencies are corrected. York University offers bridging courses (high school equivalents) to help such students meet the entry requirements of the program. Students who are missing any prerequisites should enroll in an equivalent 1500-level course, such as PHYS 1510 4.0 and/or CHEM 1500 4.0, before proceeding further.

DEGREE REQUIREMENTS

The Program Core

The Program core is defined to be (24 credits):

SC/PHYS 1010 6.00; SC/PHYS 2010 3.00; SC/PHYS 2020 3.00; SC/PHYS 2040 3.00; SC/PHYS 2060 3.00; SC/PHYS 3040 6.00.

The Program core applies to all streams within the Bachelor, Honours, and Specialized Honours Programs.

Non-Science Requirement

The non-science requirement provides a broad perspective on current scholarship and the diversity of human experience. These courses are also expected to enhance students' critical skills in reading, writing and thinking, and contribute to their preparation for post-university life. All BSc degree candidates must complete a minimum of 12 credits from two different areas of study, including at least three credits from each area, subject to the restrictions noted by the Faculty.

Visit the Faculty's website for details, particularly with respect to eligible courses:

http://www.science.yorku.ca/Calendar/General-Education/

Bachelor Program – Physics Stream

1) The program core:

See 'Program core' subsection for further explanation.

2) Additional required courses:

- CHEM 1000 3.00; CHEM 1001 3.00
- SC/CSE 1541 3.00
- SC/MATH 1013 3.00; SC/MATH 1014 3.00; SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00;
- SC/PHYS 2030 3.00; SC/PHYS 2213 3.00; SC/PHYS 3090 3.00, SC/PHYS 3220 3.00; SC/PHYS 4061 3.00;
- six credits from: SC/PHYS 3010 3.00, SC/PHYS 3020 3.00, SC/PHYS 3030 3.00.

3) Non-Science requirement: 12 credits

See 'Non-Science Requirement' subsection for further explanation.

4) Upper level requirements: a minimum of 18 credits at the 3000 level or above.

5) Additional elective credits, as required for a total of 90 credits.

Bachelor Program – Astronomy Stream

1) The program core:

See ‘Program core’ subsection for further explanation.

2) Additional required courses:

- CHEM 1000 3.00; CHEM 1001 3.00
- SC/CSE 1541 3.00
- SC/MATH 1013 3.00; SC/MATH 1014 3.00; SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00;
- SC/PHYS 1070 3.00; SC/PHYS 2070 3.00; SC/PHYS 2213 3.00; SC/PHYS 3220 3.00; SC/PHYS 4270 4.00.
- six credits from: SC/PHYS 3010 3.00, SC/PHYS 3020 3.00, SC/PHYS 3030 3.00, SC/PHYS 3090 3.00;

3) Non-Science requirement: 12 credits

See ‘Non-Science Requirement’ subsection for further explanation.

4) Upper level requirements: a minimum of 18 credits at the 3000 level or above.

5) Additional elective credits, as required for a total of 90 credits.

Specialized Honours Program – Physics Stream

1) The program core:

See ‘Program core’ subsection for further explanation.

2) Additional required courses:

- CHEM 1000 3.00; CHEM 1001 3.00
- SC/CSE 1541 3.00
- SC/MATH 1013 3.00; SC/MATH 1014 3.00; SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00;
- SC/PHYS 2030 3.00; SC/PHYS 2213 3.00; SC/PHYS 3010 3.00; SC/PHYS 3020 3.00; SC/PHYS 3030 3.00; SC/PHYS 3090 3.00, SC/PHYS 3220 3.00; SC/PHYS 4010 3.00; SC/PHYS 4020 3.00; SC/PHYS 4061 3.00;
- two of SC/PHYS 4011 3.00, SC/PHYS 4040 3.00, SC/PHYS 4050 3.00;
- either SC/PHYS 4210 3.00 or SC/PHYS 4062 3.00; and SC/PHYS 4211 3.00;
- three additional credits in PHYS courses at the 3000 level or higher.

3) Non-Science requirement: 12 credits

See ‘Non-Science Requirement’ subsection for further explanation.

4) Upper level requirements:

At least 42 credits at the 3000 or higher level, including at least 12 major credits at the 4000 level.

5) Additional elective credits, as required for a total of 120 credits.

Specialized Honours Program – Astronomy Stream

1) The program core:

See 'Program core' subsection for further explanation.

2) Additional required courses:

- CHEM 1000 3.00; CHEM 1001 3.00
- SC/CSE 1541 3.00
- SC/MATH 1013 3.00; SC/MATH 1014 3.00; SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00
- SC/PHYS 1070 3.00; SC/PHYS 2030 3.00; SC/PHYS 2070 3.00; SC/PHYS 2213 3.00;
- SC/PHYS 3010 3.00; SC/PHYS 3020 3.00; SC/PHYS 3030 3.00; SC/PHYS 3070 3.00; SC/PHYS 3090 3.00; SC/PHYS 3220 3.00; SC/PHYS 4010 3.00; SC/PHYS 4020 3.00; SC/PHYS 4061 3.00;SC/PHYS 4070 3.00; SC/PHYS 4270 4.00;
- SC/PHYS 4210 3.00 or SC/PHYS 4211 3.00;
- one of SC/PHYS 4011 3.00, SC/PHYS 4040 3.00, SC/PHYS 4050 3.00 or SC/PHYS 4120 3.00;
- one of SC/PHYS 3280 3.00, SC/PHYS 4060 3.00, SC/PHYS 4110 3.00, SC/PHYS 4330 3.00 or SC/EATS 4630 3.00;
- three additional credits from PHYS, EATS or MATH courses at the 3000 level or higher.

3) Non-Science requirement: 12 credits

See 'Non-Science Requirement' subsection for further explanation.

4) Upper level requirements:

At least 42 credits at the 3000 or higher level, including at least 12 major credits at the 4000 level.

5) Additional elective credits, as required for a total of 120 credits.

Specialized Honours Program – Applied Physics Stream

1) The program core:

See 'Program core' subsection for further explanation.

2) Additional required courses:

- CHEM 1000 3.00; CHEM 1001 3.00
- SC/CSE 1541 3.00
- SC/MATH 1013 3.00; SC/MATH 1014 3.00; SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00
- SC/PHYS 2030 3.00; SC/PHYS 2213 3.00; SC/PHYS 3010 3.00; SC/PHYS 3020 3.00; SC/PHYS 3030 3.00; SC/PHYS 3050 3.00; SC/PHYS 3090 3.00, SC/PHYS 3150 3.00;

SC/PHYS 3220 3.00; SC/PHYS 4010 3.00; SC/PHYS 4020 3.00; SC/PHYS 4050 3.00; SC/PHYS 4061 3.00; SC/PHYS 4211 3.00; SC/PHYS 4310 3.00;
- either SC/PHYS 4210 3.00 or SC/PHYS 4062 3.00;
- six credits from SC/MATH 3241 3.00, SC/PHYS 3250 3.00, SC/PHYS 3280 3.00, SC/PHYS 4120 3.00, SC/PHYS 4250 3.00.

3) Non-Science requirement: 12 credits

See 'Non-Science Requirement' subsection for further explanation.

4) Upper level requirements:

At least 42 credits at the 3000 or higher level, including at least 12 major credits at the 4000 level.

5) Additional elective credits, as required for a total of 120 credits.

Specialized Honours Program – Space Science Stream

1) The Space Science program core:

LE/EATS 1010 3.00; LE/EATS 1011 3.00; SC/MATH 1025 3.00; SC/PHYS 1070 3.00; LE/CSE 2501 1.00; LE/EATS 2030 3.00; LE/EATS 2470 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00; SC/PHYS 2010 3.00; SC/PHYS 2020 3.00; SC/PHYS 2030 3.00; SC/PHYS 2040 3.00; SC/PHYS 2060 3.00; SC/PHYS 2213 3.0

Note: alternatively the first year engineering core would be an acceptable substitute for the first year courses.

2) Additional required courses:

- CHEM 1000 3.00 or CHEM 1001 3.00
- SC/CSE 1541 3.00
- MATH 1013 3.00; MATH 1014 3.00
- PHYS 1010 6.00, SC/PHYS 3020 3.00; SC/PHYS 3040 6.00; SC/PHYS 3050 3.00; SC/PHYS 3070 3.00; SC/PHYS 3280 3.00
- three credits from: SC/PHYS 3010 3.00, SC/PHYS 3030 3.00, SC/PHYS 3080 3.00, SC/PHYS 3090 3.00, SC/PHYS 3220 3.00, SC/PHYS 4361 3.00
- at least 11 credits from: LE/EATS 4610 3.00, SC/PHYS 4010 3.00, SC/PHYS 4020 3.00, SC/PHYS 4040 3.00, SC/PHYS 4050 3.00, SC/PHYS 4070 3.00, SC/PHYS 4310 3.00, SC/PHYS 4360 3.00, SC/PHYS 4410 3.00

3) Non-Science requirement: 12 credits

See 'Non-Science Requirement' subsection for further explanation.

4) Upper level requirements:

At least 42 credits at the 3000 or higher level, including at least 12 major credits at the 4000 level.

5) Additional elective credits, as required for a total of 120 credits.

Workload

Physics & Astronomy offers a three year (90 credit) or four year (120 credit) undergraduate degree. A normal workload constitutes 5 full courses (30 credits) per year. A single credit is normally equated with one hour of classroom teaching per week over 13 weeks, or 3 laboratory hours per week for 13 weeks. A full course counts as 6 credits, and is typically three lecture hours per week for 26 weeks. Lectures are scheduled typically as 1-hour (50 minute) classes on Mondays, Wednesdays, and Fridays, or as 1.5-hour (80 minute) classes on Tuesdays and Thursdays. Traditionally, Departments offer few courses over the summer. Those courses offered tend to cater to students in their early years of study.

There has been some change in recent years as to the meaning of full-time attendance at a University. The regrettable increases in intuition fees have resulted in students engaging in part-time work while studying. For Physics & Astronomy students, this represents a daunting task given how demanding the program offerings are. Students who are forced into this situation should be prepared to extend their studies over an additional year, and should consult with members of the Department who act as advisors in order to structure their course load appropriately (to satisfy prerequisites and corequisites for courses.)

Course Selection

Physics and Astronomy studies are quite straightforward as far as course selection is concerned. For three of the streams (Physics, Applied Physics, and Astronomy), there is a common core for the first two years. Recommended timetables for each stream are detailed later in this handbook.

For advancement to graduate studies in Physics and Astronomy, the following courses are particularly important:

PHYS 3030 3.0	Statistical and Thermal Physics	PHYS 4010 3.0	Quantum Mechanics
PHYS 3090 3.0	Methods in Theoretical Physics	PHYS 4020 3.0	Electromagnetics II

GRADING SYSTEM

To help understand the grading system and calculation of averages, grades and grade-point equivalencies are listed below. The percentage equivalencies used within the Faculty of Science and Engineering are also listed.

Letter Grade	Grade-Point Value	Grade-Point Average Range	Percentage Range
A+	9	8.5+	90 - 100
A	8	7.5 – 8.4	80 - 89
B+	7	6.5 – 7.4	75 – 79
B	6	5.5 – 6.4	70 – 74
C+	5	4.5 – 5.4	65 – 69
C	4	3.5 – 4.4	60 – 64
D+	3	2.5 – 3.4	55 – 59
D	2	1.5 – 2.4	50 – 54
E	1	0.1 – 1.4	40 – 49
F	0	0	0 - 39

Repeated Courses: Check the Registrar's Office website for detailed information. (http://calendars.registrar.yorku.ca/pdfs/ug2009cal/UGCAL09-10science-rules.pdf.)

STANDARDS

To graduate in a Bachelor Program requires a minimum overall grade point average of 4.0 (C).

To declare Honours requires successful completion of at least 24 credits and a minimum cumulative credit-weighted grade-point average of 4.0 over all courses completed. This grade point average increases with credits completed as outlined below.

Honours Progression Academic Standards – Overall GPA Requirements

Fewer than 24 credits	4.0	Fewer than 84 credits	4.8
Fewer than 54 credits	4.25	At least 84 credits	5.0

To graduate in an Honours program requires successful completion of all Faculty requirements and departmental required courses and a minimum cumulative credit-weighted grade point average of 5.00 (C+) over all courses completed. In addition, a minimum cumulative credit-weighted grade point average of 5.00 (C+) over all biology courses completed is required to graduate in an Honours Double Major program where biology is the other major.

OPPORTUNITIES FOR RESEARCH

There are a variety of opportunities for undergraduate students in the Department of Physics and Astronomy to gain direct experience in research.

Natural Sciences and Engineering Research Council of Canada (NSERC)

Annually, NSERC offers Student Research Awards to foster involvement of superior undergraduates in scientific research. First, Faculty come forward with research projects for which they would like student assistance. Students who apply for a Student Research Award identify those projects of particular interest to them. After receiving an award, a student will have the opportunity to work for the duration of the summer term (May through August) on one of the selected projects. Students are paid a salary which is a combination of the award and funding from the supervisor. Information about Student Research Awards becomes available in January each year.

WorkStudy Program

York University manages a program which offers a subsidy to help faculty pay for research assistance. It is called the WorkStudy Program. For example, this program assists astronomy students who are interested in becoming involved in research activities undertaken with the York Observatories. There is no formal procedure for identifying research opportunities. Some projects are advertised online, but there may be many which are not. Students who would like to get involved in research are encouraged to talk to faculty with overlapping interests about possible opportunities for work. Many professors have projects for which they need assistance and, if an appropriate student can be found, will take the necessary steps to apply for funding through York's WorkStudy Program. Applications for Fall/Winter are due in July, and for Summer in March. For available WorkStudy positions, visit http://www.yorku.ca/careers/oncampus_jobs/.

Research at York (RAY) Program

The Research at York (RAY) Program was created to enhance both the research culture of the University and the Undergraduate student academic experience. Through the RAY Program, eligible Undergraduate students will have the opportunity to participate in research projects with Faculty members and/or fellow students, while receiving compensation at a competitive rate.

Talk to your Professors

Many Faculty members are undertaking research which could benefit from student involvement, but often don't advertise this fact. As is the case for the WorkStudy program, a simple expression of interest in research may actually lead to an opportunity for participation. Talk to your professors and see what they have to say. Some professors may be limited financially, but others may have the capacity to pay you. Volunteerism (willingness to work for free) might also be fruitful, although professors do have limits to the amount of time they can spend supervising.

PROFESSIONAL CERTIFICATION

The Canadian Association of Physicists (CAP) has instituted a professional certification process (P.Phys.) which is intended to help to raise the perceived status of a physics degree (versus an engineering degree). Full details about certification are available at https://www.cap.ca.

At present, the CAP has close to 300 certified members who use the title P.Phys. To get a P.Phys., you have to:

- be of good character
- meet the education standards established by the CAP (meaning you need an Honours B.Sc. in a physics program)
- have 3 years of physics-related work experience
- be a CAP member
- be 18 years of age or older
- pass the Professional Practice Examination (PPE)

Annually, the Department of Physics and Astronomy offers third and fourth-year undergraduate students an opportunity to write the Professional Practice Examination. A sample is on-line at www.cap.ca/cert/req.asp. Except for CAP membership, you don't have to satisfy the other requirements for certification to write the exam. The PPE does not test technical knowledge but, rather, focuses on ability to communicate as well as to understand, and show an appreciation for, ethical issues. Exams are conveyed to the CAP's Certification Committee, which will keep results on file. In this way, you will be able to apply for certification as soon as you meet the experience criteria (https://www.cap.ca).

AWARDS

Various awards are administered by the Department of Physics and Astronomy. Recipients are rewarded financially and with a record on the transcript.

- **The Embleton Award** is awarded to one or two female students of Physics, Biophysics, Engineering Physics, Astronomy, and/or Chemistry (excluding Biochemistry) who have completed 84 credits towards an Honours BSc or BASc and have earned a GPA of 6.0 (B) or better on the most recently earned 30 credits. To be eligible, applicants must be Canadian citizens, permanent residents or protected persons or have Protected Person status, be Ontario residents and demonstrate financial need.

- **The Denise Hobbins Prize** is given for outstanding achievement in PHYS 1010 6.0 Physics to commemorate Denise Hobbins, who was a physics undergraduate at York and went to Cornell University for her PhD studies in Physics. She was killed in a hit-and-run car accident shortly before defending her thesis. The prize has been set up by her family and friends.

- **The Herschel Prize** is given for outstanding achievement in PHYS 1070 3.0 Astronomy to recognize Sir William Herschel, his sister Caroline, and his son John, each of whom has made their own outstanding contributions to astronomy.

- **The R.M. Hobson Prize** is given for outstanding achievement in PHYS 2010 3.0, PHYS 2020 3.0, PHYS 2040 3.0, and PHYS 2060 3.0 to commemorate the late Robert Hobson who was Chairman of the Department of Physics for ten years. The prize has been set up by family and friends.

- **The W.J. Megaw Prize in Experimental Physics** is given for outstanding achievement in PHYS 3220 3.0 to commemorate the late William (Jim) Megaw, who was Chairman of the Department of Physics and Astronomy for ten years.

- **The Emeritus Professors' Award** is given to a student (Canadian citizen or permanent resident and Ontario resident) entering the final year of study for an Honours degree with the department, who has achieved an excellent academic record over their entire university career while maintaining a course load of at least 24 credits/year and who has demonstrated financial need.

- **The Charlene Anne Heisler Prize** is awarded to a student with at least a B+ average in two or more (science) astronomy courses, and has shown an interest in communicating science while at York University.

- **Gold Medal of the Royal Astronomical Society of Canada** The Gold Medal of The Royal Astronomical Society of Canada, Toronto Centre, will be awarded, when warranted, to the top graduating Astronomy major with a cumulative GPA greater than or equal to 7.5 who has satisfied the requirements of a 120-credit Honours B.Sc. program in the Department of Physics and Astronomy.

Information about the prizes and past winners can be found under the Undergraduate link on our website http://www.physics.yorku.ca/index.php?option=com_content&view=article&id=10&Itemid=62 or the university website http://sfs.yorku.ca/services/award_search/.

SUPPORT

Computing @ York University

York offers a wide array of computing resources and services for students. Their web site www.yorku.ca/computing/students provides a guide to finding and using services that are available to all York students. Additional services and resources are also frequently provided within specific faculties or programs.

Passport York

Passport York is York's primary method of online authentication. You must sign up for your Passport York username and password so that you can log into York's online services for students. Passport York determines which services you are able to access. If you are a new student and have not signed up for Passport York, the first time you go to an application that requires the Passport York login, click on any button that says New Student Sign Up! The next screen will ask you to login with your student number and date of birth. Follow the steps as they are listed. You will be asked to give yourself a Passport York username and password. It is important that you remember what you choose.

Undergraduate Laboratory Information

It is extremely important and required that all students who take part in science laboratories become safety conscious. Specific safety instructions and rules will appear in individual lab manuals. As certain special precautions may be necessary for particular experiments, it is essential that students always pay special attention to lab lectures so that they can observe the instructions given by their demonstrator and/or laboratory supervisor/course director.

Clubs

Please see the following websites to learn about our clubs:

- Astronomy Club www.yorku.ca/yuac/
- Physics Society www.yorku.ca/physics
- Biophysics Club www.yorku.ca/bphsclub

Bethune Writing Centre

The Bethune Writing Centre offers free one-on-one or small group instruction in academic writing, to students affiliated with Bethune College, to undergrads in the Faculty of Science and Engineering, and to undergraduate students in the Faculty of Environmental Studies.

The Bethune Writing Centre can help with the following (and much more):

- Making sense of assignment instructions;
- Writing a thesis statement;
- How to construct an argument for a critical essay or report;
- Planning and organizing the structure of an essay or scientific report;
- Drafts and proofreading;
- Active reading skills;
- Effective note-taking and reviewing of notes, using Cornell note-taking style or mind mapping;
- Effective exam revision strategies.

Appointments must be made in advance (note -- open during Reading Week). To book an appointment: Call the Bethune Academic Secretary, 736-2100 ext. 22035, or drop by the Bethune College Master's Office (205 Bethune - closed 1:00pm – 2:00 pm) Web address: http://www.yorku.ca/bethune/writing/

Student Ombuds Service (SOS)

The Student Ombuds Services (SOS) is an academic student organization in Bethune College that provides peer advising service for York students. It plays a crucial role in the transitional process of students of any year. The SOS particularly caters to the special needs of first year students coming out of high school, who need guidance in getting to know the University from an academic point of view.

Furthermore, the SOS holds seminars and presentations for the student body to give them insight and information abut the careers they are thinking about. These information sessions prove to be a great success because they prepare students for what they are going to face and what they need to work on.

The SOS office is a great resource center in itself, housing information on many careers that students may choose after their Undergraduate degree. It allows for an easy going environment with peer facilitators so students may drop in with any questions or concerns. Information on prerequisites and the admission process is readily available for various professions. In addition, referrals to campus services and people such as tutors for courses are readily available.

The SOS Office is located in 208 Bethune College. Office hours are Monday-Friday from 10:00 am – 4:00 pm. The SOS Office can also be reached by calling 416-736-5383 or by e-mailing sos@yorku.ca or http://www.yorku.ca/bethune/SOS.html.

EXCHANGE OPPORTUNITIES

York University has established exchange agreements with many universities around the world. Through such agreements, students gain opportunities to add an international component to their York degree. To participate, students apply during their second year to spend one or two terms of their third year at one of York's partner universities. Exchange opportunities exist in Asia, Australia, Europe, and South America. Especially, students should consider looking into the Baden-Wurttemburg Program, which allows students to study at the famous University of Heidelberg in Germany. Other partners which have programs which overlap ours include:

- Dublin City University (Ireland)
- Flinders University (Australia)
- University of Western Sydney (Australia)
- Monash University (Australia)
- Keele University (England)
- University of London -- Royal Holloway (England)
- University of York (England)
- Helsinki University of Technology (Finland)
- University of Helsinki (Finland)
- Copenhagen University (Denmark)
- Stockholm University (Sweden)
- Uppsala University (Sweden)

The list is continually growing, so students are encouraged to contact York International at (416) 736-5177 or http://international.yorku.ca for the latest options, as well as information session dates and application forms.

RECOMMENDED SCHEDULES

90-CREDITS B.SC. BACHELOR - PHYSICS STREAM

Required Courses and Suggested Rate of Progress

Year 1

PHYS 1010 6.0	Physics
CHEM 1000 3.0	Chemical Structure
CHEM 1001 3.0	Chemical Dynamics
CSE 1541 3.0	Introduction to Computing for the Physical Sciences
MATH 1013 3.0	Applied Calculus I
MATH 1014 3.0	Applied Calculus II
MATH 1025 3.0	Applied Linear Algebra

6.0 non-science credits

Total 30 credits

Year 2

PHYS 2010 3.0	Classical Mechanics
PHYS 2020 3.0	Electricity and Magnetism
PHYS 2030 3.0	Computational Methods for Physicists and Engineers
PHYS 2040 3.0	Relativity and Modern Physics
PHYS 2060 3.0	Optics and Spectra
PHYS 2213 3.0	Experimental Physics with Data Analysis
MATH 2015 3.0	Applied Multivariate and Vector Calculus
MATH 2271 3.0	Differential Equations for Scientists and Engineers

3.0 non-science credits

Total 27 credits**

Year 3

PHYS 3040 6.0	Modern Physics
PHYS 3090 3.0	Methods in Theoretical Physics
PHYS 3220 3.0	Experiments in Modern Physics
PHYS 4061 3.0	Experimental Techniques in Laser Physics

AND **SIX CREDITS** from the following:

PHYS 3010 3.0	Classical Mechanics
PHYS 3020 3.0	Electromagnetics I
PHYS 3030 3.0	Statistical and Thermal Physics

3.0 non-science credits

Total 24 credits**

** Additional elective credits as required for an overall total of at least **90 CREDITS**, chosen in consultation with the Department of Physics and Astronomy

90-CREDITS B.SC. BACHELOR - ASTRONOMY STREAM

Required Courses and Rate of Progress

Year 1

PHYS 1010 6.0	Physics
PHYS 1070 3.0	Fundamentals of Astronomy
CHEM 1000 3.0	Chemical Structure
CHEM 1001 3.0	Chemical Dynamics
CSE 1541 3.0	Introduction to Computing for the Physical Sciences
MATH 1013 3.0	Applied Calculus I
MATH 1014 3.0	Applied Calculus II
MATH 1025 3.0	Applied Linear Algebra

3.0 non-science credits

Total 30 credits

Year 2

PHYS 2010 3.0	Classical Mechanics
PHYS 2020 3.0	Electricity and Magnetism
PHYS 2040 3.0	Relativity and Modern Physics
PHYS 2060 3.0	Optics and Spectra
PHYS 2070 3.0	Galaxies and the Universe
PHYS 2213 3.0	Experimental Physics with Data Analysis
MATH 2015 3.0	Applied Multivariate and Vector Calculus
MATH 2271 3.0	Differential Equations for Scientists and Engineers

6.0 non-science credits

Total 30 credits

Year 3

PHYS 3040 6.0	Modern Physics
PHYS 3220 3.0	Experiments in Modern Physics
PHYS 4270 4.0	Astronomical Techniques[1]

AND **SIX CREDITS** from the following:

PHYS 3010 3.0	Classical Mechanics
PHYS 3020 3.0	Electromagnetics I
PHYS 3030 3.0	Statistical and Thermal Physics
PHYS 3090 3.0	Methods in Theoretical Physics

3.0 non-science credits

Total 22 credits**

** Additional elective credits as required for an overall total of at least **90 CREDITS**, chosen in consultation with the Department of Physics and Astronomy

[1] Students who miss PHYS 4270 4.0 due to the timing of Departmental course offerings may substitute EATS 4230 3.0 Remote Sensing of the Atmosphere, with permission of the Department of Physics and Astronomy

120 CREDITS B.SC. SPECIALIZED HONOURS - PHYSICS STREAM

Required Courses and Suggested Rate of Progress

Year 1

PHYS 1010 6.0	Physics
CHEM 1000 3.0	Chemical Structure
CHEM 1001 3.0	Chemical Dynamics
CSE 1541 3.0	Introduction to Computing for the Physical Sciences
MATH 1013 3.0	Applied Calculus I
MATH 1014 3.0	Applied Calculus II
MATH 1025 3.0	Applied Linear Algebra

6.0 non-science credits

Total 30 credits

Year 2

PHYS 2010 3.0	Classical Mechanics
PHYS 2020 3.0	Electricity and Magnetism
PHYS 2030 3.0	Computational Methods for Physicists and Engineers
PHYS 2040 3.0	Relativity and Modern Physics
PHYS 2060 3.0	Optics and Spectra
PHYS 2213 3.0	Experimental Physics with Data Analysis
MATH 2015 3.0	Applied Multivariate and Vector Calculus
MATH 2271 3.0	Differential Equations for Scientists and Engineers

6.0 non-science credits

Total 30 credits

Year 3

PHYS 3010 3.0	Classical Mechanics
PHYS 3020 3.0	Electromagnetics I
PHYS 3030 3.0	Statistical and Thermal Physics
PHYS 3040 6.0	Modern Physics
PHYS 3090 3.0	Methods in Theoretical Physics
PHYS 3220 3.0	Experiments in Modern Physics
PHYS 4061 3.0	Experimental Techniques in Laser Physics

Total 24 credits**

Year 4

PHYS 4010 3.0	Quantum Mechanics
PHYS 4020 3.0	Electromagnetics II
PHYS 4211 3.0	Advanced Experimental Physics II

AND EITHER

PHYS 4062 3.0	Atom Trapping

OR

PHYS 4210 3.0	Advanced Experimental Physics I

AND **SIX CREDITS** from the following:

PHYS 4011 3.0	Atomic and Molecular Physics
PHYS 4040 3.0	Elementary Particle Physics
PHYS 4050 3.0	Solid State Physics

AND THREE additional 3000 or 4000 level PHYS credits

Total 21 credits**

** Additional elective credits as required for an overall total of at least **120 CREDITS**, chosen in consultation with the Department of Physics and Astronomy. A minimum of 42 credits at the 3000 level or above is required to fulfil Faculty requirements.

120 CREDITS B.SC. SPECIALIZED HONOURS - APPLIED PHYSICS STREAM

Required Courses and Suggested Rate of Progress

Year 1

PHYS 1010 6.0	Physics
CHEM 1000 3.0	Chemical Structure
CHEM 1001 3.0	Chemical Dynamics
CSE 1541 3.0	Introduction to Computing for the Physical Sciences
MATH 1013 3.0	Applied Calculus I
MATH 1014 3.0	Applied Calculus II
MATH 1025 3.0	Applied Linear Algebra

6.0 non-science credits

Total 30 credits

Year 2

PHYS 2010 3.0	Classical Mechanics
PHYS 2020 3.0	Electricity and Magnetism
PHYS 2030 3.0	Computational Methods for Physicists and Engineers
PHYS 2040 3.0	Relativity and Modern Physics
PHYS 2060 3.0	Optics and Spectra
PHYS 2213 3.0	Experimental Physics with Data Analysis
MATH 2015 3.0	Applied Multivariate and Vector Calculus
MATH 2271 3.0	Differential Equations for Scientists and Engineers

6.0 non-science credits

Total 30 credits

Year 3

PHYS 3010 3.0	Classical Mechanics
PHYS 3020 3.0	Electromagnetics I
PHYS 3030 3.0	Statistical and Thermal Physics
PHYS 3040 6.0	Modern Physics
PHYS 3050 3.0	Electronics I
PHYS 3090 3.0	Methods in Theoretical Physics
PHYS 3220 3.0	Experiments in Modern Physics
PHYS 4061 3.0	Experimental Techniques in Laser Physics

AND THREE additional 3000 or 4000 level SC credits chosen in consultation with the Department of Physics and Astronomy as required for an overall total of at least 120 credits

Total 30 credits

Year 4

PHYS 3150 3.0	Electronics II
PHYS 4010 3.0	Quantum Mechanics
PHYS 4020 3.0	Electromagnetics II
PHYS 4050 3.0	Solid State Physics
PHYS 4211 3.0	Advanced Experimental Physics II
PHYS 4310 3.0	Physics or Astronomy Project

AND EITHER

PHYS 4062 3.0	Atom Trapping

OR

PHYS 4210 3.0	Advanced Experimental Physics I

AND SIX CREDITS from the following

PHYS 3250 3.0	Introduction to Space Communications
PHYS 3280 3.0	Physics of the Space Environment
PHYS 4120 3.0	Gas and Fluid Dynamics
MATH 3241 3.0	Numerical Methods I

AND THREE additional 3000 or 4000 level SC credits chosen in consultation with the Department of Physics and Astronomy as required for an overall total of at least 120 credits

Total 30 credits

A minimum of 42 credits at the 3000 level or above is required to fulfil Faculty requirements.

120 CREDITS B.SC. SPECIALIZED HONOURS - ASTRONOMY STREAM

Required Courses and Suggested Rate of Progress

Year 1

PHYS 1010 6.0	Physics
PHYS 1070 3.0	Fundamentals of Astronomy
CHEM 1000 3.0	Chemical Structure
CHEM 1001 3.0	Chemical Dynamics
CSE 1541 3.0	Introduction to Computing for the Physical Sciences
MATH 1013 3.0	Applied Calculus I
MATH 1014 3.0	Applied Calculus II
MATH 1025 3.0	Applied Linear Algebra

3.0 non-science credits

Total 30 credits

Year 2

PHYS 2010 3.0	Classical Mechanics
PHYS 2020 3.0	Electricity and Magnetism
PHYS 2030 3.0	Computational Methods for Physicists and Engineers
PHYS 2040 3.0	Relativity and Modern Physics
PHYS 2060 3.0	Optics and Spectra
PHYS 2070 3.0	Galaxies and the Universe
PHYS 2213 3.0	Experimental Physics with Data Analysis
MATH 2015 3.0	Applied Multivariate and Vector Calculus
MATH 2271 3.0	Differential Equations for Scientists and Engineers

3.0 non-science credits

Total 30 credits

Year 3

PHYS 3010 3.0	Classical Mechanics
PHYS 3020 3.0	Electromagnetics I
PHYS 3030 3.0	Statistical and Thermal Physics
PHYS 3040 6.0	Modern Physics
PHYS 3090 3.0	Methods in Theoretical Physics
PHYS 3220 3.0	Experiments in Modern Physics
PHYS 4061 3.0	Experimental Techniques in Laser Physics

AND EITHER

PHYS 4070 3.0 Stars and Nebulae[1]

OR

PHYS 4270 4.0 Astronomical Techniques[2]

Total 27 or 28 credits**

Year 4

PHYS 3070 3.0	Planets and Planetary Systems
PHYS 4010 3.0	Quantum Mechanics
PHYS 4020 3.0	Electromagnetics II

AND EITHER

PHYS 4070 3.0 Stars and Nebulae

OR

PHYS 4270 4.0 Astronomical Techniques

AND EITHER

PHYS 4210 3.0 Advanced Experimental Physics I

OR

PHYS 4211 3.0 Advanced Experimental Physics II

AND THREE CREDITS from the following:

PHYS 4011 3.0	Atomic and Molecular Physics
PHYS 4040 3.0	Elementary Particle Physics
PHYS 4050 3.0	Solid State Physics
PHYS 4120 3.0	Gas and Fluid Dynamics

AND THREE CREDITS from the following:

PHYS 3280 3.0	Physics of the Space Environment
PHYS 4060 3.0	Time Series and Spectral Analysis
PHYS 4110 3.0	Dynamics of Space Vehicles
PHYS 4330 3.0	Radio Science and Techniques for Space Exploration[3]
EATS 4630 3.0	Image Processing for Remote Sensing and Photogrammetry

AND **THREE** additional PHYS, ESSE, or MATH credits at the 3000 or 4000 level

6.0 non-science credits

Total 30 or 31 credits

** Additional elective credits as required for an overall total of at least **120 CREDITS**, chosen in consultation with the Department of Physics and Astronomy.

[1] Students who miss PHYS 4070 3.0 due to an internship may substitute PHYS 3080 3.0 – Atmospheric Radiation and Thermodynamics, with permission of the Department of Physics and Astronomy

[2] Students who miss PHYS 4270 4.0 due to an internship may substitute EATS 4230 3.0 – Remote Sensing of the Atmosphere, with permission of the Department of Physics and Astronomy

[3] PHYS 4330 3.0 will be offered in alternate years. Students should enrol in the year it is offered, and PHYS 3280 3.0 in the year PHYS 4330 3.0 is not offered.

A minimum of 42 credits at the 3000 level or above is required to fulfil Faculty requirements.

120 CREDITS B.SC. SPECIALIZED HONOURS – SPACE SCIENCE STREAM

Required Courses and Suggested Rate of Progress

(See the calendar issued by the Department of Earth and Space Science & Engineering for the Space Science Stream offered by that department.)

Note: Required non-science general education credits are deferred into upper years or the summer.

Year 1

PHYS 1010 6.0	Physics
PHYS 1070 3.0	Fundamentals of Astronomy
CSE 1541 3.0	Introduction to Computing for the Physical Sciences
EATS 1010 3.0	The Dynamic Earth and Space Geodesy
EATS 1011 3.0	Introduction to Atmospheric Science
MATH 1013 3.0	Applied Calculus I
MATH 1014 3.0	Applied Calculus II
MATH 1025 3.0	Applied Linear Algebra
AND EITHER	
CHEM 1000 3.0	Chemical Structure
OR	
CHEM 1001 3.0	Chemical Dynamics

Total 30 credits

Year 2

PHYS 2010 3.0	Classical Mechanics
PHYS 2020 3.0	Electricity and Magnetism
PHYS 2030 3.0	Computational Methods for Physicists and Engineers
PHYS 2040 3.0	Relativity and Modern Physics
PHYS 2060 3.0	Optics and Spectra
PHYS 2213 3.0	Experimental Physics with Data Analysis
CSE 2501 1.0	Fortran and Scientific Computing
EATS 2030 3.0	Geophysics and Space Science
EATS 2470 3.0	Introduction to Continuum Mechanics
MATH 2015 3.0	Applied Multivariate and Vector Calculus
MATH 2271 3.0	Differential Equations for Scientists and Engineers

Total 31 credits

Year 3

PHYS 3020 3.0	Electromagnetics I
PHYS 3040 6.0	Modern Physics
PHYS 3050 3.0	Electronics I
PHYS 3070 3.0	Planets and Planetary Systems
PHYS 3150 3.0	Electronics II
PHYS 3250 3.0	Introduction to Space Communications
PHYS 3280 3.0[1]	Physics of the Space Environment

OR

PHYS 4330 3.0[1]	Radio Science and Techniques for Space Exploration

AND THREE CREDITS from the following

PHYS 3010 3.0	Classical Mechanics
PHYS 3030 3.0	Statistical and Thermal Physics
PHYS 3080 3.0	Atmospheric Radiation and Thermodynamics
PHYS 3090 3.0	Methods in Theoretical Physics
PHYS 3220 3.0	Experiments in Modern Physics
PHYS 4361 3.0	Space Mission Design

6.0 non-science credits

Total 30 credits

Year 4

PHYS 4110 3.0	Dynamics of Space Vehicles
PHYS 3280 3.0[1]	Physics of the Space Environment

OR

PHYS 4330 3.0[1]	Radio Science and Techniques for Space Exploration
PHYS 4350 6.0	Space Hardware

AND AT LEAST EIGHT CREDITS from

PHYS 4010 3.0	Quantum Mechanics
PHYS 4020 3.0	Electromagnetics II
PHYS 4040 3.0	Elementary Particle Physics
PHYS 4050 3.0	Solid State Physics
PHYS 4070 3.0	Stars and Nebulae
PHYS 4120 3.0	Gas and Fluid Dynamics
PHYS 4270 4.0	Astronomical Techniques
PHYS 4310 3.0	Physics or Astronomy Project
PHYS 4360 3.0	Payload Design
PHYS 4410 3.0	Space Geodynamics
EATS 4610 3.0	Global Positioning Systems

6.0 non-science credits

Total 29 credits

* PHYS 4330 3.0 will be offered in alternate years. Students should enrol in the year it is offered, and PHYS 3280 3.0 in the year PHYS 4330 3.0 is not offered.
A minimum of 42 credits at the 3000 level or above is required to fulfil Faculty requirements.

DEGREE COMBINATIONS

B.SC. HONOURS MAJOR, DOUBLE MAJOR, MAJOR/MINOR PROGRAMS

Students can combine Physics or Astronomy with most other subjects in the Faculty of Science and Engineering (FSE), or the Faculty of Liberal Arts and Professional Studies (LA&PS.) The set of courses required for Physics or Astronomy as part of a double-major program are well-defined, and identical for each such program. Particularly popular combinations are with Computer Science, Chemistry, and Applied Mathematics.

The required courses for a Major in Physics or Astronomy (to be combined with a Major from another discipline) are the following:

PHYSICS MAJOR REQUIREMENTS *
(48 PHYS CREDITS)

SC/PHYS 1010 6.0 (or SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0 with a minimum grade of C); SC/PHYS 2010 3.0; SC/PHYS 2020 3.0; SC/PHYS 2040 3.0; SC/PHYS 2060 3.0; SC/PHYS 2213 3.0; SC/PHYS 3040 6.0; SC/PHYS 3220 3.0; SC/PHYS 4061 3.0. Six credits from: SC/PHYS 3010 3.0, SC/PHYS 3020 3.0, SC/PHYS 3030 3.0, SC/PHYS 3090 3.0; SIX PHYS 4000 level credits; at least NINE credits from PHYS courses at the 4000 level, for an overall total of at least 48 credits from PHYS courses; the requirements for the second major or the minor, in Honours Double Major or Honours Major/Minor BSc programs.

ASTRONOMY MAJOR REQUIREMENTS *
(54 PHYS CREDITS)

SC/PHYS 1010 6.0 (or PHYS 1410 6.0 or SC/PHYS 1420 6.0 with a minimum grade of C); SC/PHYS 1070 3.0; SC/PHYS 2010 3.0; SC/PHYS 2020 3.0; SC/PHYS 2040 3.0; SC/PHYS 2060 3.0; SC/PHYS 2070 3.0; SC/PHYS 2213 3.0; SC/PHYS 3040 6.0; SC/PHYS 3220 3.0; SC/PHYS 4270 4.0. Six credits from: SC/PHYS 3010 3.0, SC/PHYS 3020 3.0, SC/PHYS 3030 3.0, SC/PHYS 3090 3.0; EIGHT additional credits in PHYS at the 4000 level for an overall total of at least 54 credits from PHYS courses; the requirements for the second major or the minor, in Honours Double Major or Honours Major/Minor BSc programs.

OTHER REQUIREMENTS OR PREREQUISITES FOR BOTH STREAMS *

SC/CSE 1540 3.0; SC/MATH 1013 3.0; SC/MATH 1014 3.0; SC/MATH 1025 3.0; SC/MATH 2015 3.0;
SC/MATH 2271 3.0; SC/CHEM 1000 3.0; SC/CHEM 1001 3.0.

POSSIBLE DOUBLE MAJOR COMBINATIONS WITHIN HONOURS B.SC.

Physics and Astronomy Major (Physics Stream or Astronomy Stream) and
Biology
Chemistry
Computer Science
Earth and Atmospheric Science
Applied Mathematics
Mathematics
Science and Technology Studies
Statistics

***** Consult Department for further information

POSSIBLE MAJOR-MINOR COMBINATIONS WITHIN B.SC. HONOURS

Physics and Astronomy Major (Physics Stream or Astronomy Stream) and				
Faculty of Science and Engineering	**Faculty of Health**	**Faculty of Liberal Arts and Professional Studies***	**Faculty of Fine Arts***	**Faculty of Environmental Studies**
Biology	Health Science	Various	Various	Environmental Studies
Chemistry	Health Studies	*Consult Department for further information	*Consult Department for further information	
Computer Science				
Earth and Atmospheric Science	Kinesiology			
Applied Mathematics	Psychology			
Mathematics				
Mathematics for Commerce				
Mathematics for Education				
Science and Technology Studies				
Statistics				
Geography				

PHYSICS AND ASTRONOMY MINOR REQUIREMENTS

One can also combine a Minor in Physics or Astronomy with a Major from another discipline in FSE in a BSc (Hons.) program or within BA (Hons.), BES (Hons.) or BFA (Hons.) programs offered by other Faculties. The minimum requirements are listed together with cognate requirements:

PHYSICS MINOR REQUIREMENTS
(33 PHYS CREDITS)

SC/PHYS 1010 6.0 (or SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0 with a minimum grade of C); SC/PHYS 2010 3.0; SC/PHYS 2020 3.0; SC/PHYS 2040 3.0; SC/PHYS 2060 3.0; SC/PHYS 2213 3.0; SC/PHYS 3040 6.0; SC/PHYS 3220 3.0. Three credits from: SC/PHYS 3010 3.0; SC/PHYS 3020 3.0; SC/PHYS 3030 3.0; SC/PHYS 3090 3.0 for an overall total of 33 credits from PHYS courses.

ASTRONOMY MINOR REQUIREMENTS
(39 PHYS CREDITS)

SC/PHYS 1010 6.0 (or SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0 with a minimum grade of C); SC/PHYS 1070 3.0; SC/PHYS 2010 3.0; SC/PHYS 2020 3.0; SC/PHYS 2040 3.0; SC/PHYS 2060 3.0; SC/PHYS 2070 3.0; SC/PHYS 2213 3.0; SC/PHYS 3040 6.0. Three credits from: SC/PHYS 3070 3.0; SC/PHYS 4270 4.0. Three credits from: SC/PHYS 3010 3.0; SC/PHYS 3020 3.0; SC/PHYS 3030 3.0; SC/PHYS 3090 3.0 for an overall total of at least 39 credits from PHYS courses.

OTHER REQUIREMENTS OR PREREQUISITES FOR BOTH STREAMS

SC/MATH 1013 3.0; SC/MATH 1014 3.0; SC/MATH 1025 3.0; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

COURSE DESCRIPTIONS

PHYSICS

PHYS 1010 6.0 PHYSICS

Topics include linear, rotational and oscillatory motion; Newtonian mechanics; gravitation; electrostatics; magnetostatics; electric current and induction; heat; geometrical and physical optics and sound. Differential and integral calculus and vector algebra are used. This course covers fewer topics than SC/PHYS 1410 6.00, but covers them in greater depth. It should be taken by all those likely to enrol in 2000-level physics courses. Includes three hour laboratory component normally in alternating weeks.

Content

1. Motion in one, two and three dimensions
2. Newton's laws
3. Work, energy, power
4. Momentum
5. Torque and rotational motion
6. Angular momentum
7. Oscillations
8. Gravitation
9. Thermodynamics
10. Static electricity
11. Capacitance
12. DC circuits
13. Magnetic fields
14. Electromagnetic induction
15. Waves and sound
16. Electromagnetic waves
17. Physical and geometrical optics

In addition, some concepts of modern physics are introduced interspersed throughout.

Required Text

N. Giordano, *College Physics (Special Package.)* Nelson Publications; 2009.

Recommended Text

College Physics Student Solutions Manual/Study Guide Vol. 1 and 2. Nelson Publications; 2010.

PHYS 1010 6.0 PHYSICS (Cont'd)

Prerequisites

OAC Physics or 12U Physics or SC/PHYS 1510 4.0.

Corequisites

SC/MATH 1013 3.0 and SC/MATH 1014 3.0, or SC/MATH 1505 6.0, or equivalent.

Course Credit Exclusion

SC/PHYS 1410 6.0 and SC/PHYS 1420 6.0.

Two terms. Six credits.

Three lecture hours per week in both terms; three laboratory hours in alternate weeks in both terms; one tutorial hour each week in both terms.

PHYS 1070 3.0 FUNDAMENTALS OF ASTRONOMY

An introduction to the foundations of astronomy and astrophysics. The course covers basic measurement concepts and techniques, and gives an overview of the properties and workings of planets and stars.

Content

1. Introduction: space and time, celestial sphere, positions and motions of celestial bodies, seasons
2. The Earth and Moon: motions, geometry, tides, eclipses, structure
3. Observational Methods: telescopes, CCDs, photometry, spectroscopy
4. The Solar System: overview: planetary motions, Kepler's Laws, rocky planets, gas giants, extra-solar planets
5. Small Bodies and the Origin of the Solar System: asteroids, comets, meteors, formation of solar system
6. Matter and Radiation: structure of the atom, nature of radiation, relation between matter and radiation
7. The Sun: basic properties, structure, energy source, activity, relevance to Earth
8. The Stars: motions and distances, the spectral sequence, temperature and luminosity, the Hertzsprung-Russell diagram, star clusters

Required Text

R. Freedman. *Universe, 8th ed*. WH Freeman; 2008.

Prerequisites

12U Physics or OAC Physics or SC/PHYS 1510 4.0.

Prerequisites or Corequisites

SC/MATH 1013 3.0 or SC/MATH 1505 6.0 or equivalent.

Prior to Fall 2009:
Prerequisite or corequisite: AS/SC/MATH 1013 3.00 or AS/SC/MATH 1505 6.00 or equivalent.

One term. Three credits.

Three lecture hours per week. One tutorial hour per week. Some day sessions at the Observatory.

PHYS 1410 6.0 PHYSICAL SCIENCE

A survey of physics. Topics include kinematics, dynamics, momentum and energy for linear and rotational motion; elementary kinetic theory and thermodynamics; static and current electricity; waves and physical and geometrical optics**;** elements of modern physics. This is a calculus-based course recommended for students unlikely to take 2000-level PHYS courses. It includes a three hour laboratory component, normally in alternating weeks.

Content

1. Vectors
2. Motion and forces
3. Work and energy
4. Torque and rotational motion
5. Linear and angular momentum
6. Oscillatory motion
7. Elasticity
8. Collisions
9. Rotational Motion
10. Gases and Fluids
11. Static electricity
12. Capacitance
13. DC circuits
14. Magnetic field
15. Magnetic force
16. Faraday's Law of Induction
17. Waves
18. Sound
19. Electromagnetic waves
20. Physical and geometrical optics
21. Elements of modern physics

Required Text

N. Giordano, *College Physics (Special Package.)* Nelson Publications; 2009.

PHYS 1410 6.0 PHYSICAL SCIENCE (Cont'd)

Prerequisites

12U Physics or OAC Physics or SC/PHYS 1510 4.0; MHF4U Advanced Functions and MCV4U Calculus and Vectors, or 12U Advanced Functions and Introductory Calculus, or OAC Algebra and OAC Calculus, or SC/MATH 1505 6.0, or SC/MATH 1520 3.0.

Course Credit Exclusion

SC/PHYS 1010 6.0 and SC/PHYS 1420 6.0.

Two terms. Six credits.

Three lecture hours per week in both terms, three laboratory hours in alternate weeks in both terms, one tutorial hour each week in both terms.

PHYS 1420 6.0 PHYSICS WITH APPLICATIONS TO LIFE SCIENCES

A survey of physics in which many fundamental concepts are emphasized through applications to the life sciences. Topics include kinematics, dynamics, momentum and energy for linear and rotational motion; elementary kinetic theory and thermodynamics; static and current electricity; waves and physical and geometrical optics; elements of modern physics. This is a calculus-based course recommended for students unlikely to take 2000-level PHYS courses. It includes a three-hour laboratory component, normally in alternating weeks.

Content

1. Motion in one, two and three dimensions
2. Newton's laws
3. Work, energy, and power
4. Torque and rotational motion
5. Linear momentum and angular momentum
6. Elasticity and oscillatory motion
7. Fluids
8. Gravitation
9. Thermal physics
10. Static electricity
11. Capacitance
12. DC circuits
13. Magnetic fields and magnetic force
14. Electromagnetic induction
15. Mechanical waves and sound
16. Light
17. Physical and geometrical optics
18. Nuclear physics

Required Text

R. Serway C. Vuille, *College Physics (Special Package.)* Nelson Education; 2009.

Prerequisites

12U Physics or OAC Physics or SC/PHYS 1510 4.0; MHF4U Advanced Functions and MCV4U Calculus and Vectors, or 12U Advanced Functions and Introductory Calculus, or OAC Algebra and OAC Calculus, or SC/MATH 1505 6.0, or SC/MATH 1520 3.0.

Course Credit Exclusion

SC/PHYS 1010 6.0, SC/PHYS 1410 6.0.

Two terms. Six credits.

Three lecture hours per week in both terms, three laboratory hours in alternate weeks in both terms, one tutorial hour each week in both terms.

PHYS 1470 3.0 HIGHLIGHTS OF ASTRONOMY

This introductory course on modern astronomy for science students surveys the nature, formation, and evolution of planets, stars, galaxies, and the universe by highlighting selected topics of wide interest and importance.

Content

Understanding astronomy
- 1.1 Discovering the night sky
- 1.2 Gravitation and the motion of planets
- 1.3 Light and telescopes
- 1.4 Atomic physics and spectra

2. The Solar system
   - 2.1 Formation of the solar system
   - 2.2 The terrestrial planets
   - 2.3 The outer planets
   - 2.4 Vagabonds of the solar system
   - 2.5 Our sun
   - 2.6 Planets outside our solar system
3. The stars
   - 3.1 Characterizing stars
   - 3.2 The lives of stars
   - 3.3 The deaths of stars
   - 3.4 Neutron stars, gamma-ray bursts & black holes
4. The Universe
   - 4.1 Our milky way galaxy
   - 4.2 Galaxies and dark matter in the universe
   - 4.3 Quasars, active galactic nuclei, relativists jets and supermassive black holes
   - 4.4 Cosmology, the big bang and the fate of the Universe
   - 4.5 Search for extraterrestrial life

Required Text

N. Comins, W. Kaufmann III, *Discovering the Universe, 8th ed.* Freeman Publications, 2009.

Prerequisites or Corequisites

SC/MATH 1013 3.0 or SC/MATH 1505 6.0 or equivalent.

Note: This course is not open to any student who has passed or is taking SC/PHYS 1070 3.0.

One term. Three credits.

Three lecture hours per week. One tutorial hour per week.

PHYS 1510 4.0 INTRODUCTION TO PHYSICS

An introductory course for students lacking adequate preparation for SC/PHYS 1010 6.00, SC/PHYS 1410 6.00, or SC/PHYS 1420 6.00. Topics include dynamics (forces and motion, including oscillatory motion), energy and momentum, gravitational, electric and magnetic fields, the wave nature of light, and geometric optics. No calculus is used, but vectors are used extensively.

Content

1. Linear motion
2. Laws of motion
3. Rotational motion
4. Oscillatory motion
5. Energy, work and momentum
6. Properties of matter
7. Temperature and heat
8. Geometrical optics
9. Electricity and magnetism
10. Structure of atoms and nuclear energy

Required Text

R. Serway, J. Faughn and C. Vuille, *College Physics (Special Package.)* Nelson Education; 2009.

Prerequisites

Ontario Grade 11 Functions and Relations (new curriculum) or Ontario Grade 12 Advanced Mathematics (old curriculum).

Note: May not be taken by any student who has taken or is currently taking another University course in physics.

One term. Four credits.

Includes one lab hour per week.

PHYS 2010 3.0 CLASSICAL MECHANICS

Newtonian mechanics of mass points and rigid bodies. Accelerated reference frames and rotational motion, centrifugal and Coriolis forces. Central force motion in celestial mechanics. Euler's equations: precession and nutation in the gyroscope.

Content

1. One dimensional motion of a particle
2. The harmonic oscillator, forced oscillations
3. Motion in two and three dimensions
4. Non-inertial reference frames and dynamics
5. Central forces: applications to celestial mechanics
6. Systems of particles – Centre of mass and angular momentum
7. Moment of inertia and rigid-body rotation

Required Text

G. Fowles, G. Cassiday, *Analytical Mechanics*. Thomson Publications; 2004.

Prerequisites

SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; SC/MATH 1014 3.0 or equivalent; SC/MATH 1025 3.0 or equivalent; SC/MATH 2015 3.0 or equivalent.

Corequisite

SC/MATH 2271 3.0.

Prior to Fall 2010:
Prerequisites: SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; AS/SC/MATH 1014 3.0 or equivalent; AS/SC/MATH 1025 3.00 or equivalent;
Corequisite: SC/MATH 2015 3.00.

One term. Three credits.

Three lecture hours per week. One tutorial hour per week.

PHYS 2020 3.0 ELECTRICITY AND MAGNETISM

The elements of electric and magnetic fields are developed together with DC and AC circuit theory.

Content

1. Coulomb’s Law
2. Electric field
3. Gauss' Law
4. Electric potential
5. Electrostatic energy
6. Capacitors and dielectrics
7. Current, resistance, Ohm's law, dc circuits
8. Magnetic fields
9. Biot Savart Law
10. Ampere's Law
11. Magnetostatic energy
12. Faraday's Law
13. Magnetic materials
14. Inductance
15. AC circuits, rms relations, impedance, q factor
16. Displacement current
17. Maxwell's equations

Required Text

D. Halliday, R. Resnick, J. Walker. *Physics: Extended Version, 8th ed.* John Wiley and Sons Publications; 2007.

Prerequisites

SC/PHYS 1010 6.0 or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0.

Corequisite

SC/MATH 2015 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0.
Corequisite: AS/SC/MATH 2015 3.00.

One term. Three credits.

Three lectures hours per week. One tutorial hour per week.

PHYS 2030 3.0 COMPUTATIONAL METHODS FOR PHYSICISTS AND ENGINEERS

The symbolic and numeric computing environments provided by Maple and MATLAB are used to solve problems in Mechanics and Electromagnetism.

Content

This course provides a practical introduction to symbolic and numeric computing methodologies for solving real problems in science and engineering. Examples and exercises including radioactive decay, oscillatory motion and chaos, orbit and trajectory analysis, quantum mechanics and vibrations and waves of musical instruments are developed from the course text and implemented in the MATLAB programming environment. MATLAB's Simulink and Maple toolboxes are utilized for time-dependent numerical simulation and symbolic manipulation respectively.

1. Introduction to MATLAB, Simulink and Maple
2. Solving symbolic problems in Calculus
3. Numerical simulation: modeling time-dependent problems
4. Monte-Carlo simulation: integral solutions by numerical search
5. Bayesian probability: estimating probability density functions and modeling uncertainty
6. Function optimization, solution searches, guesswork and practical estimation theory

Required Text

N. Giordano, H. Nakanishi, *Computational Physics, 2nd ed.* Prentice Hall: 2005.

Prerequisites

SC/PHYS 1010 6.0 or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.00; One of LE/CSE 1020 3.0 or LE/SC/CSE 1541 3.0; SC/MATH 1014 3.0 or equivalent.

Corequisite

SC/MATH 2015 3.0 or equivalent.

Prior to Fall 2009:
Prerequisites: SC/PHYS 1010 6.0 or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; One of AK/AS/SC/CSE 1020 3.0, AK/AS/SC/COSC 1020 3.0, AK/AS/SC/CSE 1540 3.0 or AK/AS/SC/COSC 1540 3.0; AS/SC/MATH 1014 3.0 or equivalent.
Corequisite: AS/SC/MATH 2015 3.00 or equivalent.

One term. Three credits.

Three lecture hours per week.

PHYS 2040 3.0 RELATIVITY AND MODERN PHYSICS

An introduction to the theories of relativity and quantum mechanics. Relativistic concepts of space, time and energy are presented. The quantum nature of radiation and matter is introduced.

Content

1. Einstein's postulates, time dilation, and space contraction
2. Relativistic kinematics
3. Relativistic dynamics
4. Quantization of matter and radiation
5. The Bohr atom
6. Matter waves and the Uncertainty Principle

Required Text

S. Thornton, A. Rex, Modern Physics for Scientists and Engineers, 3rd ed. Nelson Publications: 2005.

References

R. Resnick and D. Halliday, Basic Concepts in Relativity and Early Quantum Theory (Macmillan, 1992)

T. Moore, *Six Ideas That Shaped Physics*, 2nd ed. (McGraw-Hill, 2003).

Prerequisites

SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.00.

One term. Three credits.

Three lecture hours per week. One tutorial hour per week.

This course is the beginning of a sequence of courses in modern physics, including SC/PHYS 3040 6.0, SC/PHYS 4010 3.0, SC/PHYS 4011 3.0 and SC/PHYS 4040 3.0.

PHYS 2060 3.0 OPTICS AND SPECTRA

An introductory course in optics covering the following topics: wave nature of light, reflection, refraction, spherical mirrors and lenses, interference, diffraction, polarization, introduction to lasers.

Content

1. Electromagnetic waves
2. Propagation of light, Doppler effect
3. Geometrical optics, index of refraction
4. Interference and diffraction
5. Polarization
6. Gratings and interferometers
7. Physics of lasers
8. Atomic spectra
9. Laser cooling

Required Text

D. Halliday, R. Resnick, J. Walker. *Physics: Extended Version, 8th ed.* John Wiley and Sons Publications; 2007.

References

E. Hecht, *Optics,* Addison Wesley Publications; 1979

F. Pedrotti, L. Pedrotti, *Introduction to Optics,* 2nd ed. Prentice-Hall; 1993

Prerequisites

SC/PHYS 1010 6.0 or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.00; SC/MATH 1014 3.0 or equivalent; SC/MATH 1025 3.0 or equivalent.

Prior to Fall 2009:
Prerequisites: SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; SC/MATH 1014 3.00 or equivalent; SC/MATH 1025 3.0 or equivalent.

One term. Three credits.

Three lecture hours per week. One tutorial hour per week.

PHYS 2070 3.0 GALAXIES AND THE UNIVERSE

An introduction to the structure, evolution and origin of galaxies, aggregates of galaxies, and the universe as a whole. Relevant details of stellar evolution are encompassed. Topics such as supernovae, pulsars, black holes, quasars, density waves, the cosmic web, cosmic expansion and dark constituents of the universe are included.

Content

1. Stellar properties relevant to studies of galaxies: H-R diagram; star clusters; mass and luminosity; age; evolution; variables; supernovae; black holes; standard candles.
2. Introduction to galaxies and their organization: Milky Way; how galaxies were discovered; what galaxies are; stellar populations; organization, including Large-Scale Structure in the Universe.
3. Properties of galaxies: morphology; clustering; nature versus nurture; changes with Redshift; distances; stars, gas, and dust; nuclear activity; internal motions and implications for mass; dark matter.
4. Evolution of galaxies: chemistry; spiral structure.
5. Cosmology: Olbers' Paradox; the Redshift; Hubble's Law; Hubble's Constant; the Cosmic Microwave Background; the Cosmological Principle; the Scale Factor; the Density Parameter; geometry; dark matter; dark energy; the Big Bang; formation and evolution of structure.

Required Text

R.A. Freedman, R.M. Geller, and W J. Kaufmann III, *Universe, 9th ed.* Freeman Publications; 2011

Prerequisites

12U Physics or OAC Physics or SC/PHYS 1510 4.0; SC/PHYS 1070 3.0, or SC/PHYS 1470 3.00 and permission of the instructor.

One term. Three credits.

Three lecture hours per week. One project requiring at least two evening sessions at the observatory.

PHYS 2211 1.0 EXPERIMENTAL ELECTROMAGNETISM

An introductory laboratory course for second-year students. The course consists of 10 experiments covering basic concepts of electromagnetism.

Content

Orientation (oscilloscopes and error propagation)

1. Coulomb's Law
2. Motion of electrons in electric and magnetic fields
3. Simple DC circuits
4. Classical Hall Effect
5. The Biot Savart Law
6. Earth's magnetic field
7. Force on a current carrying wire placed in a magnetic field
8. Faraday's Law
9. RC and RL circuits
10. Electrical resonance

Required Text

J. Taylor, *An Introduction to Error Analysis*.
University Science Books; 1997

Prerequisite

SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.00.

Corequisite

SC/PHYS 2020 3.0

Course credit exclusion:

SC/PHYS 2213 3.0.

Normally three laboratory hours per week.

Notes

Course material pertaining to SC/PHYS 2211 1.0 is covered in SC/PHYS 2020 3.0 .

All Physics & Astronomy majors/minors must register in SC/PHYS 2213 3.0 (effective September 2005.)

Students whose programs require 2 credits of 2000-level experimental physics take both SC/PHYS 2211 1.0 and SC/PHYS 2212 1.0.

PHYS 2212 1.0 EXPERIMENTAL PHYSICS

An introductory laboratory course based on lasers and modern optics. Includes different experiments than those completed in SC/PHYS 2211 1.0.

Content

The course also includes an introduction to Laser Safety.

1. Photoelectric effect
2. Fourier analysis
3. Lenses
4. Diffraction of light
5. Michelson Interferometer
6. Microwaves
7. Fabry Perot Interferometer
8. Polarization of light
9. Acousto-optic effect
10. Spatial profile of a laser beam

Required Text

J. Taylor, *An Introduction to Error Analysis*.
University Science Books; 1997

Prerequisite

SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; SC/PHYS 2211 1.0.

Corequisite

SC/PHYS 2060 3.0 recommended.

Course credit exclusion:

SC/PHYS 2213 3.0.

Normally three laboratory hours per week.

Notes

Course material pertaining to SC/PHYS 2212 1.0 is covered in SC/PHYS 2060 3.0.

All Physics & Astronomy majors/minors must register in SC/PHYS 2213 3.0 (effective September 2005.)

Students whose programs require 2 credits of 2000-level experimental physics take both SC/PHYS 2211 1.0 and SC/PHYS 2212 1.0.

PHYS 2213 3.0 EXPERIMENTAL PHYSICS WITH DATA ANALYSIS

Experiments in Electricity and Magnetism and in Modern Optics. Basic methods for analyzing experimental data and understanding statistical and systematic errors.

Content

Experiments:

1. Classical Hall Effect
2. Coulomb's Law
3. Motion of electrons in electric and magnetic fields
4. Simple DC circuits
5. The Biot Savart Law
6. Earth's magnetic field
7. Force on a current carrying wire placed in a magnetic field
8. Faraday's Law
9. RC and RL circuits
10. Electrical resonance
11. Photoelectric effect
12. Fourier analysis
13. Lenses
14. Diffraction of light
15. Michelson Interferometer
16. Microwaves
17. Fabry-Perot Interferometer
18. Polarization of light
19. Acousto-optic effect
20. Spatial profile of a laser beam

Lectures:

1. Precision and accuracy, estimating uncertainties, reporting discrepancies, significant figures
2. General formulae for error propagation
3. Characteristics of a histogram of data – mean, standard deviation and standard deviation of the mean
4. Estimation of random and systematic errors
5. Properties of the Gaussian distribution
6. Addition of errors in quadrature
7. Weighted averages and criterion for rejection of data
8. Least squares fitting – straight line and other functions
9. Statistics of spontaneous decays (e.g. radioactivity)
10. Chi-Squared tests for discrete and continuous variables

Required Text

J. Taylor, *An Introduction to Error Analysis*. University Science Books; 1997.

Prerequisite

SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0.

Corequisite

SC/PHYS 2020 3.0; SC/PHYS 2060 3.0 recommended.

Course Credit Exclusion

SC/PHYS 2211 1.0; SC/PHYS 2212 1.0.

Three laboratory hours per week, one lecture hour every two weeks.

PHYS 3010 3.0 CLASSICAL MECHANICS

Intermediate classical mechanics, including dynamics of particles and systems of particles. Lagrange's equations and Hamilton's equations.

Content

1. Calculus of variations
2. Lagrangian and Hamiltonian dynamics
3. Central force problem and collisions
4. Dynamics of rigid bodies
5. Coupled oscillations and normal modes
6. Introduction to nonlinear oscillations and chaos

Required Text

S. Thornton, J. Marion, *Classical Dynamics of Particles and Systems,* Thomson Publications; 2003.

Prerequisites

SC/PHYS 2010 3.0; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 2010 3.0; AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 3020 3.0 ELECTROMAGNETICS I

Electrostatic and magnetostatic fields, derived from charge and current distributions studied in vacuum and in material media.

Content

1. Vector calculus in Cartesian, cylindrical and spherical polar coordinates
2. Electrostatic fields and electrostatic potentials from discrete and continuous charge distributions in vacuo
3. Work and energy in electrostatics
4. Laplace's equation, solutions to Laplace's equation by separation of variables in Cartesian and spherical geometry
5. Multipole expansions of electrostatic fields
6. Electrostatic fields in dielectric material, bound charge, polarization and displacement fields, linear media
7. Magnetostatic fields from distributed currents in vacuo
8. The Lorentz force law, the Biot Savart law, the magnetic vector potential
9. Multipole expansions of the magnetic vector potential
10. Magnetic fields in matter, bound currents, magnetization, the "auxiliary field", linear media

Required Text

D.J. Griffiths, *Introduction to Electrodynamics,* 3rd ed. Prentice Hall; 1999.

Prerequisites

SC/PHYS 2020 3.0; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 2020 3.0; AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 3030 3.0 STATISTICAL AND THERMAL PHYSICS

Statistical mechanics of systems of large numbers of elements. Probability, ensembles, fluctuations. Applications: spin magnetism, electrons in metals, radiation, specific heats of solids. Transport theory.

Content

1. Review of classical thermodynamics: three laws, specific heats, adiabatic processes, heat engines
2. Quantum states of weakly interacting particles,
3. Pauli exclusion principle
4. Entropy and probability, Boltzmann's relation, two-level systems, Boltzmann distribution
5. Distribution of quantum states, subsystems and reservoirs, partition function, free energies, entropy of a two-level system, systems of harmonic oscillators, classical perfect gas, diatomic molecules
6. Equipartition theorem, kinetic theory of gases, transport properties
7. Planck radiation law, Bose and Fermi gases

Required Text

K. Stowe, An Introduction to Thermodynamics and Statistical Mechanics, 2nd ed. Cambridge University Press: 2007.

References

Brehm, J.J. and Mullin, W.J. *Introduction to the Structure of Matter: A Course in Modern Physics.* John Wiley and Sons; 1989

Reif, F. *Fundamentals of Statistical and Thermal Physics.* McGraw–Hill; 1965

Prerequisites

SC/PHYS 2020 3.0; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 2020 3.0; AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 3040 6.0 MODERN PHYSICS

Survey of the basis of contemporary physics: introduction to elementary wave mechanics, and the quantum theory of atoms, molecules, solids, nuclei, elementary wave mechanics and elementary particles.

Content

1. Phenomenological basis of quantization; Planck's hypothesis; matter waves; particle-wave duality; probabilistic interpretation; uncertainty principle.
2. Schrodinger equation; stationary & non-stationary states; expectation values; 1-D box; finite square well; eigenfunctions and eigenvalues; harmonic oscillator; barrier penetration; 3-D box; operators & commutation relations.
3. Central forces; separation of variables; quantization of angular momentum; intrinsic spin; addition of angular momenta; hydrogen atom; dipole transitions; many-electron atoms; Pauli exclusion principle.
4. Selected topics and applications from the following: molecular, condensed matter, and nuclear physics

Required Text

R. Scherrer, *Quantum Mechanics: An Accessible Introduction.* Addison-Wesley Publications; 2006

Prerequisites

SC/PHYS 2010 3.0; SC/PHYS 2020 3.0; SC/PHYS 2060 3.0; SC/MATH 1025 3.0, SC/MATH 2015 3.0; SC/ MATH 2271 3.0

Corequisite

SC/PHYS 3090 3.0 recommended.

Prior to Fall 2009:
Prerequisites: SC/PHYS 2010 3.0; SC/PHYS 2020 3.0; SC/PHYS 2060 3.0; AK/AS/SC/MATH 1025 3.0; AK/AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0.
Corequisite: SC/PHYS 3090 3.00 recommended.

Two terms. Six credits.

Three lecture hours per week. One tutorial hour per week.

PHYS 3050 3.0 ELECTRONICS I

Introduction to physical electronics including DC and AC circuit theory and network analysis; bandpass filters; introduction to the p-n junction and semiconductor devices: diodes, DC power supplies, transistors, analysis and design of basic amplifiers, operational amplifiers. With laboratory exercises.

Content

1. Electronic instruments and measurements
2. DC and AC circuit analysis
3. Filters
4. The p-n junction and diodes
5. Diode applications
6. Transistors
7. Switches and amplifiers

Required Text

M. Plonus, *Electronics and Communications for Scientists and Engineers*. Harcourt Academic Press; 2001

References

D. Bugg, *Electronics: Circuits, Amplifiers, and Gates.* Institute of Physics Publishing; 1991

M. Gussow, *Schaum's Outline of Theory and Problems of Basic Electricity.* McGraw-Hill; 1983

J. Edminister, *Schaum's Outline of Theory and Problems of Electric Circuits*. McGraw-Hill; 2003

A. Sedra, K. Smith, *Micro-electronic Circuits, 5th ed.* Oxford University Press; 2004

J. Cathey, *Schaum's Outline of Theory and Problems of Electronic Devices and Circuits.* McGraw-Hill; 2002

S. Nasar, *3000 Solved Problems in Electrical Circuits.* McGraw-Hill; 1998

Prerequisites

SC/PHYS 1010 6.0; SC/PHYS 2020 3.0 and SC/PHYS 2211 1.0.

Course Credit Exclusion

SC/ENG 2200 3.0.

Includes three laboratory hours in alternative weeks.

PHYS 3070 3.0 PLANETS AND PLANETARY SYSTEMS

Survey of planetary astrophysics. Topics include: the formation and evolution of planetary systems; the search for and discovery of extra-solar planets; current knowledge of the atmospheres, interiors and surfaces of planets, satellites and minor bodies within the Solar System.

Content

1. Definition of a planet
2. Planetary formation and the origin of the Solar System
3. Solar System dynamics
4. Chemical evolution of Solar System
5. Planetary surfaces, interiors and atmospheres
6. Planetary satellite evolution
7. Planetary ring systems
8. Cratering history of Solar System
9. Extrasolar planets: including detection methods (spectroscopic, photometric); general properties; current results from literature
10. Evolution of a habitable planet; rare earth hypothesis

Required Text

I. de Pater, J. Lissauer, *Planetary Sciences, 2nd ed.* Cambridge University Press: 2010.

Additional material will be drawn from the research literature.

References

J. Beatty, C. Petersen, A. Chaikin, *The New Solar System,* 4th ed. Sky Publications Corporation; 1999

W. Hartmann, *Moons and Planets, 4th ed.* Wadsworth Publishing Company; 1999

T. Kepner, Extrasolar Planets: A Catalog of Observations in Other Solar Systems. McFarland and Company; 2005

J. Landstreet, Physical Processes in the Solar System: An Introduction to the physics of Asteroids, Comets, Moons and Planets. Keenan & Darlington Publications; 2003

J. Lewis, *Physics & Chemistry of the Solar System*. Academic Press; 2004

PHYS 3070 3.0 PLANETS AND PLANETARY SYSTEMS (Cont'd)

I. de Pater, J. Lissauer, *Planetary Sciences*. Cambridge University Press; 2001

R. Smoluchowski, J. Bahcall, M.Matthes, *The Galaxy and the Solar System.*(University of Arizona Press; 1986

R. Taylor, *Solar System Evolution: A New Perspective, 2nd ed.* Cambridge University Press; 2001

J. Wood, *The Solar System*. Prentice Hall; 2000

Prerequisites

SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.00 or SC/PHYS 1420 6.00.

Prerequisites or Corequisites

AS/SC/MATH 2015 3.0; AK/AS/SC/MATH 2271 3.0.

Prior to Fall 2009:
Prerequisite: SC/PHYS 1010 6.0 or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; SC/PHYS 1070 3.0,
Prerequisite(s) or corequisite: AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 3080 3.0 ATMOSPHERIC RADIATION AND THERMODYNAMICS

Applications of basic thermodynamic principles to dry and moist atmospheric situations. Solar (short wave) and terrestrial (long wave) radiation with respect to absorption and scattering processes involving atmospheric atoms, molecules, aerosol particles and clouds.

Required Text

J. Wallace, P. Hobbs, Atmospheric Science: An Introductory Survey, 2nd ed. Elsevier; 2006.

Prerequisites

SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

PHYS 3090 3.0 METHODS IN THEORETICAL PHYSICS

Methods of classical and modern theoretical physics are introduced to solve problems such as heat diffusion, wave propagation, modes of vibrating strings and membranes, electromagnetic potentials from charge distributions, Schrödinger waves and eigenvalues, and the angular distribution of cosmic radiation.

Content

1. Coordinate systems appropriate for physical symmetries
2. Basic fluid flow: vectors, divergence, gradient, and curl
3. Fluid flow using complex variables
4. Dynamics, forces, and specific differential equations
5. Vibrating strings, quantum waves, and Fourier series
6. Vibrating membranes, heat flow, and Bessel functions
7. Fourier transforms and power spectra, such as for time-varying phenomena
8. Laplace transforms and physical modelling, such as for electric circuits and control analyses

Required Text

S. Lea, *Mathematics for Physicists.* Nelson Publication; 2003.

Prerequisite

SC/PHYS 2020 3.0.

Corequisite

SC/PHYS 3040 6.0.

One term. Three credits.

Three lecture hours per week.

PHYS 3150 3.0 ELECTRONICS II

The concept of feedback and its use in circuits employing operational amplifiers; analysis/design of such circuits, including amplifiers, filters, oscillators, pulse generators; digital concepts and logic circuits with applications to data manipulation (computers) and storage. Laboratory exercises and project.

Content

1. Feedback principles
2. Characteristics of operational amplifiers
3 .Operational amplifier circuits
4. Basic digital concepts
5. Basic digital logic circuits
6. Analogue/digital conversion
7. Microcomputer fundamentals

Required Text

M. Plonus, *Electronics and Communications for Scientists and Engineers*. Harcourt Academic Press; 2001.

References

D. Bugg, *Electronics: Circuits, Amplifiers, and Gates.* Institute of Physics Publishing; 1991

M. Gussow, *Schaum's Outline of Theory and Problems of Basic Electricity.* McGraw-Hill; 1983

J. Edminister, *Schaum's Outline of Theory and Problems of Electric Circuits*. McGraw-Hill; 2003

A. Sedra, K. Smith, *Micro-electronic Circuits, 5th ed.* Oxford University Press; 2004

J. Cathey, *Schaum's Outline of Theory and Problems of Electronic Devices and Circuits.* McGraw-Hill; 2002

S. Nasar, *3000 Solved Problems in Electrical Circuits.* McGraw-Hill; 1998

Prerequisite

SC/PHYS 1010 6.0; and SC/PHYS 3050 3.0 recommended.

Course Credit Exclusion

SC/ENG 2210 3.0.

Includes three laboratory hours in alternate weeks.

PHYS 3220 3.0 EXPERIMENTS IN MODERN PHYSICS

A selection of experiments in fluid mechanics, electromagnetism, optics, and atomic, nuclear, and particle physics. Analysis of the data and detailed write-ups are required. One lecture hour which is devoted to techniques of data analysis and three laboratory hours per week.

Required Text

J. Taylor, *An Introduction to Error Analysis*. University Science Books; 1997.

Prerequisite

SC/PHYS 2020 3.0; SC/PHYS 2060 3.0; SC/PHYS 2213 3.0.

Corequisite

SC/PHYS 3040 6.0.

Course Credit Exclusion

SC/PHYS 3210 6.0.

One term. Three credits.

One lecture hour per week. 4 experiments are performed through the semester. These labs each normally take 3 to 6 hours of laboratory time in addition to reviewing the laboratory manual and other background material in advance of the lab.

PHYS 3250 3.0 INTRODUCTION TO SPACE COMMUNICATIONS

The course covers all aspects of communications between spacecraft and ground stations. Topics include orbital aspects of satellite communications, communications components of satellites and interplanetary spacecraft, ground stations, transmission, reception, link equation, modulation, multiplexing techniques and access to a satellite

Content

1. History and overview of present status
2. Orbital aspects of satellite communications
3. Spacecraft
4. Earth station
5. Communications link
6. Modulation and multiplexing techniques
7. Multiple access to a satellite

Required Text

D. Roddy, *Satellite Communications,* 4th ed. McGraw-Hill; 2006.

Prerequisite

SC/PHYS 2020 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 3280 3.0 PHYSICS OF THE SPACE ENVIRONMENT

An introduction to the physical processes of the upper atmosphere, the ionosphere, the magnetosphere and the heliosphere, and the interactions that occur with space vehicles that traverse these regions of space.

Content

1. Atmospheric structure and composition particularly at spacecraft altitudes in the ionosphere, thermosphere and exosphere
2. Essentials of solar physics
3. Solar electromagnetic radiation
4. Solar wind and its interactions with the terrestrial atmosphere
5. Terrestrial magnetism
6. Solar-terrestrial phenomena
7. Magnetosphere

Required Text

No required text.

References

T.F. Tascione, *Introduction to the Space Environment*, 2nd ed. Krieger; 1994

Prerequisites

SC/PHYS 2020 3.0; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 2020 3.0, AS/SC/MATH 2015 3.0, AS/SC/MATH 2271 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 3320 3.0 MICROSYSTEMS TECHNOLOGY

The course covers the principles and implementations of miniaturised sensors and actuators in a range of physical domains, such as optical, magnetic, thermal, and mechanical systems. Examples include electronic cameras, micro-electro-mechanical systems, thermal microsystems, and display technologies.

Content

1. Introduction: Introduction to microsystems; general principles of transduction; definitions
2. Fabrication & Micromachining Technology: Overview of CMOS technology relevant to microsystems, materials properties, micromachining technology
3. Mechanical Microsystems: Overview of mechanics and mechanical properties of materials; mechanisms of mechanical transconduction; mechanical sensors (e.g. accelerometer, gyroscope, pressure sensor); mechanical actuators (e.g. electrostatic micromotors, micromirrors)
4. Optical Microsystems: Optical detection; optical sensors (CCD, CMOS, non-silicon); optical actuators – displays (LCD, field emission, LED, organic)
5. Radiation Detection: Interaction of radiation (e.g. X-ray, ionizing radiation) with matter; radiation sensors (large area, space applications)
6. Thermal Microsystems: Review of heat transfer mechanisms; transduction principles; thermal sensors (junction bases sensors, thermo-mechanical and –resistive sensors); thermal imaging (IR image sensors); thermal actuators (e.g. Peltier cooler)
7. Magnetic Microsystems: Magnetic sensors (magnetoresistive, magnetostrictive, Hall effect); magnetic actuators (e.g. RF passive components, read/write heads)
8. Chemical and Fluidic Microsystems: Chemical sensors (e-nose); fluidic sensors (flow sensors)

PHYS 3320 3.0 MICROSYSTEMS TECHNOLOGY (Cont'd)

Required Text

No required text.

Reference

G. Kovacs, *Micromachined Transducers Handbook.* McGraw-Hill Publications; 1998

Prerequisites

SC/PHYS 2020 3.0; SC/PHYS 2211 1.0; SC/PHYS 2060 3.0 recommended; SC/PHYS 2212 1.0 recommended.

Corequisite

SC/PHYS 3050 3.0 recommended.

PHYS 3330 3.0 MATERIALS FOR SPACE APPLICATIONS

This course covers the behaviour of materials relevant to the engineering of spacecraft. Material responses to thermal, mechanical, vacuum, electrical and ionizing radiation stresses are discussed. Engineering analysis tools and environmental models are also covered.

Required Text

V.L Piscane, *The Space Environment and Its Effects on Space Systems*. AIAA; 2008.

References

A.C. Tribble, *The Space Environment Implications for Spacecraft Design,* Revised and Expanded edition (Princeton University Press, 2003).

Prerequisite

SC/CHEM 1000 3.0, SC/PHYS 1010 6.0, LE/SC/ENG 2002 3.0 or permission of the instructor.

One term. Three credits.

PHYS 3900 0.0 PHYSICS OR ASTRONOMY INTERNSHIP WORK TERM

This experiential education course reflects the work term component of the Technology Internship Program (TIP.) Qualified Honours students gain relevant work experience as an integrated complement to their academic studies, reflected in the requirements of a learning agreement and work term report. Students are required to register in this course for each four month work term, with the maximum number of work term courses being four (i.e. 16 months.) Students in this course receive assistance from the Career Centre prior to and during their internship, and are also assigned a Faculty Supervisor/Committee.

Prerequisite

Enrollment is by permission only. Criteria for permission include: 1. That students have successfully completed at least nine PHYS credits at the 3000 level or higher, and have a GPA of at least 5.00 in PHYS courses overall; 2. That students are enrolled full-time in the Honours program prior to beginning their internship and have attended the mandatory preparatory sessions as outlined by the Career Centre; 3. That students have not been absent for more than two consecutive years as a full-time student from their Honours degree studies; 4. That upon enrolling in this course students have a minimum of 9 credits remaining toward their Honours degree and needs to return as a full-time student for at least one academic term to complete their degree after completion of their final work term.

Note: This is a pass/fail course, which does not count for degree credit. Registration in SC/PHYS 3900 0.00 provides a record on the transcript for each work term.

PHYS 4010 3.0 QUANTUM MECHANICS

Physical concepts and mathematical foundations of quantum mechanics. Emphasis on approximation methods, treatment of angular momentum, spin and their couplings. Introduction to relativistic quantum mechanics and scattering theory.

Content

- Postulates of quantum mechanics
- Operators
- Expectation values
- Uncertainty
- Time-evolution operators
- Particle in a box
- Bohr correspondence principle
- Dirac notation
- Hilbert space: linearity, inner product, norm, completeness
- Hermitian operators: reality of eigenvalues, orthogonality of eigenfunctions
- Mathematical aside: fourier transforms
- Momentum representation
- Commutators
- General uncertainty relations
- Time development: wavefunctions, expectation values, Ehrenfest theorem
- Wave packets: gaussian wave packet
- Conservation laws: energy, momentum, angular momentum, parity
- Translation operator, rotation operator, parity operator
- Harmonic oscillator – creation, annihilation operators
- Tunneling: transmission resonances
- WKB approximation: connection formulae, Airy functions
- Angular momentum: commutation relations, J_+ and J_-
- Spherical harmonics
- Hydrogen atom
- Variational method
- Matrix mechanics
- Spin
- Addition of angular momenta
- Perturbation theory: time-independent, degenerate, time-dependent
- Relativistic quantum mechanics: Dirac equation, Klein-Gordon equation

PHYS 4010 3.0 QUANTUM MECHANICS (Cont'd)

Required Text

D. Griffiths, *Introduction to Quantum Mechanics,* 2nd ed. Pearson Education; 2005.

Prerequisite

SC/PHYS 3040 6.0.

Prerequisites or Corequisites

SC/PHYS 3020 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4011 3.0 ATOMIC AND MOLECULAR PHYSICS

Application of quantum mechanics to atomic and molecular structure. One-electron systems, many electron atoms, Hartree-Fock approximation, fine structure, hyperfine structure, atom-laser interactions.

Integrated with: GS/PHYS 5050 3.0

Content

1. Introduction: the Schroedinger hydrogen problem revisited
2. Time-independent perturbation theory, non-degenerate and degenerate, with applications to atomic physics (Stark effect)
3. Interaction of atoms with electromagnetic fields
4. Time-dependent perturbation theory
5. First-order radiation processes: absorption, stimulated and spontaneous emission
6. Photons: a brief introduction to field quantization
7. Many-electron atoms and molecules: identical particles, simple structure
(self-consistent field) models
8. Relativistic hydrogen problem: the Dirac equation

Recommended Text

R.Liboff, *Introductory Quantum Mechanics, 4th ed*. Addison-Wesley Publications; 2002.

Cohen-Tannoudji, C. *Quantum Mechanics*, Vol 2 John Wiley and Sons; 1992

Prerequisite

SC/PHYS 4010 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4020 3.0 ELECTROMAGNETICS II

Time–dependent electric and magnetic fields, Maxwell's differential equations in linear, isotropic, homogeneous conductors and dielectrics; the radiation and transmission of electromagnetic energy; relativistic transformations; scalar diffraction theory.

Content

1. Electromagnetic induction; Maxwell's equations; boundary conditions
2. Conservation laws for energy and linear and angular momentum in electrodynamics; Poynting's theorem; Maxwell stress tensor
3. Electromagnetic wave propagation in vacuum; in linear dielectrics; in conductors
4. Absorption and dispersion in conductors and in dielectrics
5. Electromagnetic wave transmission in wave guides; co-axial transmission lines
6. Potentials and fields; gauge transformations; retarded potentials; Lienard-Wiechert potentials
7. Electromagnetic radiation; electric dipole radiation; magnetic dipole radiation; radiation from an arbitrary source; radiation reaction
8. Special relativity; relativistic mechanics; Minkowski space-time; four vectors and four tensors in space-time; relativistic electrodynamics; Maxwell's equations in covariant form.

Required Text

D.J. Griffiths, *Introduction to Electrodynamics,* 3rd ed. Prentice Hall; 1999.

Prerequisites

SC/PHYS 2040 3.0; SC/PHYS 3020 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4040 3.0 ELEMENTARY PARTICLE PHYSICS

The properties of the fundamental particles (quarks and leptons), and the forces between them are studied. Topics include the interactions of particles with matter, symmetry principles and experimental techniques.

Integrated with: GS/PHYS 5040 3.0.

Content

1. Nuclear phenomenology: properties of nuclei, masses and sizes of nuclei, stability and instability of nuclei; some nuclear models
2. Nuclear radiation: alpha decay and barrier penetration, beta decay and intro to weak interactions , gamma decay
3. Energy deposition in media: energy loss of charged particles, interaction of photons, particle detectors and accelerators
4. Conservation laws and Invariance principles: electric charge, baryon number, particles and antiparticles, isospin, P.C.T. conservation and CP violation
5. Standard Model: quarks and leptons, quark content of mesons and baryons, symmetries and symmetry breaking, colour force, deep inelastic scattering; structure functions
6. Beyond the standard model (time permitting)

Required Text

Griffiths, D. Introduction to Elementary Particles, 2nd ed., Wiley-VCH; 2008

References

Coughlan, C.D. and Dodd, J.E. *The Ideas of Particle Physics.* Cambridge University Press; 1991

Das, A. and Ferbel, T. *Introduction to Nuclear and Particle Physics*. John Wiley and Sons; 1993

H. Frauenfelder, E. Henley, *Subatomic Physics* Prentice Hall; 1991.

Martin, B.R. and Shaw, G. *Particle Physics.* John Wiley and Sons; 2006

Perkins, D. *Introduction to High Energy Physics*. Cambridge University Press; 2000

Williams, W.S.C. *Nuclear and Particle Physics.* Oxford University Press; 1991

Prerequisites

SC/PHYS 2040 3.0; SC/PHYS 4010 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4050 3.0 SOLID STATE PHYSICS

The structural, mechanical, thermal, electrical and magnetic properties of crystalline solids are studied.

Integrated with: GS/PHYS 5100 3.0

Content

1. Molecular forces and interatomic bonding
2. Crystal structure, diffraction and the reciprocal lattice
3. Elastic constants and elastic waves: continuum approach
4. Phonon and lattice vibrations: monatomic and diatomic lattices; local phonon modes; thermal properties of insulators; lattice specific heat, thermal conductivity; thermal expansion
5. Free electron theory of metals: Fermi surface; Fermi–Dirac distribution function; specific heat of metals; electrical conductivity; thermal conductivity, band theory of solids: Kronig–Penny model; effective mass; conductors, insulators, semi–metals, and semi–conductors; holes; magnetic properties
6. Superconductivity: BCS theory (Introduction only)

Required Text

C. Kittel, *Introduction to Solid State Physics,* 8^{th} ed. John Wiley and Sons; 2005.

References

Ashcroft and Mermin, Solid State Physics Modeling: Introduction to Solid State Physics. Harcourt College Publishers; 1976

Blakemore, J.S. *Solid State Physics*, 2nd ed. Saunders; 1974

Ali Omar, M. *Elementary Solid State Physics*. Addison Wesley; 1975

Prerequisites

SC/PHYS 3030 3.0; SC/PHYS 4010 6.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4060 3.0 TIME SERIES AND SPECTRAL ANALYSIS

Treatment of discrete sampled data involving correlation, convolution, spectral density estimation, frequency domain filtering, and Fast Fournier Transforms.

Integrated with: GS/ESS 5020 3.0

Content

1. Discrete, Equispaced Time Series: Power and energy signals, wavelets; convolution and the z–transform; expected value, autocorrelation and cross correlation; impulse, white noise and World decomposition; time reversal; properties of wavelets; linear, optimum filtering; deconvolution, shaping and spiking filters.
2. Fourier Methods: Finite Fourier transform; Fourier transform effects of sampling and record length; digital frequency filtering; the power spectrum; fast Fourier transform.

References

E. Kanasewich, *Time Sequence Analysis in Geophysics.* University of Alberta Press; 1981

A. Enders, *Multichannel Time Series Analysis with Digital Computer Programs*. Holden–Day; 1978

A. Enders, S. Treital, *Geophysical Signal Analysis.* Prentice Hall Inc.; 1980

Prerequisites

LE/SC/CSE 1540 3.0 or LE/CSE 1541 3.0 or equivalent programming experience; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

Course Credit Exclusions

LE/CSE 3451 4.0; LE/CSE 3451 3.0; SC/MATH 4130B 3.0 SC/MATH 4930C 3.0.

Prior to Fall 2009:
Prerequisites: AK/AS/SC/CSE 1540 3.0 or equivalent programming experience; AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0
Course Credit Exclusions: AK/AS/SC/CSE 3451 4.0; AK/AS/SC/CSE 3451 3.0; AS/SC/MATH 4130B 3.0; AS/SC/MATH 4930C 3.0

PHYS 4061 3.0 EXPERIMENTAL TECHNIQUES IN LASER PHYSICS

Involves a selection of experiments in laser physics, with emphasis on techniques necessary for trapping neutral atoms with lasers.

Integrated with: GS/PHYS 5061 3.0

Required Text

Course Kit.

Recommended Texts
Atomic Physics
1) B. H. Bransden, C. J. Joachain, Physics of Atoms and Molecules (Longman)
2) A. Corney, Atomic and Laser Spectroscopy (Oxford)

Lasers
1) A. E. Seigman, Lasers (University Science Books)
2) O. Svelto, Principles of Lasers (Plenum)
3) D. C. O'Shea, W. R. Callen, W. T. Thodes, Introduction to Lasers and Their Applications (Adison-Wesley)
4) R. S. Quimby, Photonics and Lasers (Wiley)
5) C. C. Davis, Lasers and Electro-Optics (Cambridge)

Optics
1) E. Hecht, Optics (Addison Wesley)
2) Pedrotti and Pedrotti, Introduction to Optics (Prentice Hall)
3) G. R. Fowles, Introduction to Modern Optics (Dover)
4) M. Mansuripur, Classical Optics (Cambridge)

Error Analysis
1) J. R. Taylor, An Introduction to Error Analysis (University Science Books)

General Interest
1) D. W. Preston and E. R. Dietz, The Art of Experimental Physics (Wiley)

Prerequisites

SC/PHYS 2211 1.0 and SC/PHYS 2212 1.0, or SC/PHYS 2213 3.0; SC/PHYS 2020 3.0; SC/PHYS 2060 3.0.

Corequisites

SC/PHYS 3040 6.0.

One term. Three credits.

Includes two three hours laboratory sessions per week.

PHYS 4062 3.0 ATOM TRAPPING

Involves trapping atoms with lasers and investigating the properties of laser-cooled atoms. The course includes a set of lectures that cover theoretical concepts including basic properties of two-level atoms, radiation pressure, the laser cooling force, magnetic trapping, and the dipole force.

Integrated with: GS/PHYS 5062 3.0

Required Text

Course Kit.

Recommended Texts

Light-Matter Interactions and Laser Spectroscopy
1) W. Demtroder, Laser Spectroscopy (Springer)
2) P. W. Milonni and J. H. Eberly, Lasers (Wiley)
3) L. Allen and J. H. Eberly, Optical Resonance and Two-Level Atoms (Dover)
4) H. J. Metcalf and P. van der Straten, Laser Cooling and Trapping (Springer)
5) C. J. Foot, Atomic Physics (Oxford)
6) A. Yariv, Quantum Electronics (Wiley)

Atomic Physics
1) B. H. Bransden, C. J. Joachain, Physics of Atoms and Molecules (Longman)
2) A. Corney, Atomic and Laser Spectroscopy (Oxford)

Lasers
1) A. E. Seigman, Lasers (University Science Books)
2) O. Svelto, Principles of Lasers (Plenum)
3) D. C. O'Shea, W. R. Callen, W. T. Thodes, Introduction to Lasers and Their Applications (Addison-Wesley)
4) R. S. Quimby, Photonics and Lasers (Wiley)
5) C. C. Davis, Lasers and Electro-Optics (Cambridge)

Optics
1) E. Hecht, Optics (Addison Wesley)
2) Pedrotti and Pedrotti, Introduction to Optics (Prentice Hall)
3) G. R. Fowles, Introduction to Modern Optics (Dover)
4) M. Mansuripur, Classical Optics (Cambridge)

Error Analysis
1) J. R. Taylor, An Introduction to Error Analysis (University Science Books)

General Interest
1) D. W. Preston and E. R. Dietz, The Art of Experimental Physics (Wiley)

PHYS 4062 3.0 ATOM TRAPPING (Cont'd)

Prerequisite

SC/PHYS 4061 3.0.

One term. Three credits.

Includes sixteen three hour laboratory sessions over a period of eight weeks.

PHYS 4070 3.0 STARS AND NEBULAE

The astrophysics of radiating matter in the universe. The course covers radiation processes, radiative transfer, interstellar matter, stellar atmospheres and stellar interiors.

Integrated with: GS/PHYS 5090 3.0

Content

1. Interactions of matter with radiation
2. Emission lines and absorption lines
3. Overview of interstellar matter
4. Theory and observation of gaseous nebulae
5. Theory and observation of stellar atmospheres
6. Stellar interiors and stellar evolution

Required Text

None.

Recommended Text

E. Bohm-Vitense, *Introduction to Stellar Astrophysics,* Volumes 2 and 3. Cambridge University Press; 1992

Osterbrock, D. and Ferland, G. *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei,* 2nd ed. University Science Books; 2005

References

D. Gray, *Observation and Analysis of Stellar Photospheres*. Cambridge University Press; 1992
J. Irwin, *Astrophysics: Decoding the Cosmos.* Wiley Interscience; 2007
G. Rybicki, A. Lightman, *Radiative Processes in Astrophysics.* Wiley Interscience; 1979
T. Swihart, *Radiation Transfer and Stellar Atmospheres*. Pachart Publishing House; 1981

Prerequisites

SC/PHYS 1070 3.0; SC/PHYS 3030 3.0; SC/PHYS 3040 6.0.

Prerequisite or Corequisite

SC/PHYS 3040 6.0.

One term. Three credits.

Three lecture hours per week.

Normally offered in alternate years.

PHYS 4110 3.0 DYNAMICS OF SPACE VEHICLES

This course presents a coherent and unified framework for mathematical modeling and analysis of space vehicles. The course can be divided into two main parts: orbit dynamics and attitude dynamics and control. The topics covered by this course include two-body problem, coordinate transformation, orbital elements, perturbation theory, orbital maneuvers, relative motion and rendezvous, interplanetary trajectories, rocket dynamics, and attitude dynamics and control. Spacecraft dynamics and control problems of practical interests are treated from a dynamical systems point of view. This course will focus on a comprehensive treatment of spacecraft dynamics and control problems and their practical solutions.

Content

1. Overview and Introduction
2. Particle dynamics/dynamics of point mass
3. Rocket vehicle dynamics
4. Two body problem
5. Orbital elements
6. Coordinate transformations
7. Orbital perturbation theory
8. Orbital maneuvers
9. Relative motion and rendezvous
10. Interplanetary trajectories, Launch windows
11. Rigid-body dynamics
12. Satellite attitude dynamics
13. Attitude control system
14. Introduction to stability analysis

    Possible additional topics: Reentry dynamics, N-body problem, Orbit determination

Required Text

W. Wiesel, *Space Flight Dynamics,* 2nd ed. McGraw-Hill; 1997.

Prerequisites

SC/PHYS 2010 3.0 or SC/EATS 2470 3.0; SC MATH 2015 3.0; SC/MATH 2271 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 2010 3.0 or SC/EATS 2470 3.0; AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4120 3.0 GAS AND FLUID DYNAMICS

Fundamental laws; conservation of mass, momentum and energy, vortex motion; incompressible, compressible and viscous flows, turbulent flow, surface waves.

Content

1. Introduction: basis of continuum model, pressure isotropy, compressibility, viscosity
2. Mass, momentum, and energy conservation equations
3. Hydrostatics
4. Velocity potential, vortex motion, stream function
5. Potential flows of incompressible fluid in two and three dimensions
6. Viscous incompressible flows: Navier–Stokes equation, solutions for pipe and channel flows, laminar and turbulent boundary layers
7. Nonviscous compressible flows: shock waves, expansion flows

Required Text

Merle C. Potter, David C. Wiggert, B. Ramadan, *Mechanics of Fluids, 4th ed.* CL-Engineering; 2011

Prerequisites

SC/PHYS 2010 3.0 or LE/EATS 2470 3.0; SC/MATH 2015 3.0; SC/MATH 2271 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 2010 3.0 or AS/SC/EATS 2470 3.0; AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4210 3.0 ADVANCED EXPERIMENTAL PHYSICS I

Selected advanced experiments in physics related to topics in solid state physics, atomic spectroscopy, microwaves, low-noise measurements, superconductivity, and nuclear and particle physics.

References

A.C. Melissinos, *Experiments in Modern Physics* (Academic Press, 1975).

D.W. Preston and E.R. Dietz, *The Art of Experimental Physics* (John Wiley and Sons, 1991).

Prerequisites

SC/PHYS 3210 6.0, or SC/PHYS 3220 3.0 and SC/PHYS 4061 3.0; registration in an Honours Program in Physics or Astronomy.

Course Credit Exclusion

SC/PHYS 4210 6.0.

Open laboratory hours.

PHYS 4211 3.0 ADVANCED EXPERIMENTAL PHYSICS II

Selected advanced experiments in physics related to topics in solid state physics, atomic spectroscopy, microwaves, low-noise measurements, superconductivity, and nuclear and particle physics.

References

Melissinos, A.C. *Experiments in Modern Physics*. Academic Press; 1975

Preston, D.W. and Dietz, E.R. *The Art of Experimental Physics*. John Wiley and Sons; 1991

Prerequisite

SC/PHYS 3210 6.0, or SC/PHYS 3220 3.0 and SC/PHYS 4061 3.0; registration in an Honours Program in Physics or Astronomy.

Course Credit Exclusion

SC/PHYS 4210 6.0.

Open laboratory hours.

PHYS 4270 4.0 ASTRONOMICAL TECHNIQUES

An introduction to modern astronomical instrumentation, observational methods, data analysis, and numerical methods. In addition to weekly lectures, the course provides students with hands–on experience with both observational and theoretical techniques of modern astronomy.

Integrated with: GS/PHYS 5390 3.0

Content

1. Radiation and telescopes
2. Detectors, especially CCDs and NIR arrays
3. Photometry
4. Spectroscopy
5. Astrometry
6. Statistics

References

G. Walker, *Astronomical Observations: An Optical Perspective.* Cambridge University Press; 1987

C. Kitchin, *Astrophysical Techniques*. Hilger; 1991

S. Howell, *Handbook of CCD Astronomy*. Cambridge University Press; 2000

W. Press, *Numerical Recipes: The Art of Scientific Computing*, many editions. Cambridge University Press

W. Smart, *Textbook on Spherical Astronomy*. Cambridge University Press; 1971

Prerequisites

SC/PHYS 1070 3.0; AS/SC/MATH 2271 3.0.

Prerequisite or Corequisite

SC/PHYS 3220 3.0.

Prior to Fall 2009:
Prerequisites: SC/PHYS 1070 3.0; AS/SC/MATH 2271 3.0.
Prerequisite or corequisite: SC/PHYS 3220 3.0.

Includes several laboratory exercises.

Normally offered in alternate years.

PHYS 4310 3.0 PHYSICS OR ASTRONOMY PROJECT

A supervised research endeavour, either theoretical or experimental, in physics or astronomy. The project follows consultation with a faculty member who agrees to supervise.

Note

Open to students in the final year of the Physics, Applied Physics or Astronomy streams of an Honours Physics and Astronomy program.

One term. Three credits.

PHYS 4330 3.0 RADIO SCIENCE AND TECHNIQUES FOR SPACE EXPLORATION

The theory and application of modern radio science and radio techniques in space exploration and space navigation. Topics include signal processing, radio astronomy fundamentals, Deep Space Network instrumentation, antenna theory, arrays, Very Long Baseline Interferometry, spacecraft navigation, radar systems, range, range rate and the radar equation.

Integrated with: GS/PHYS 6190 3.0

Content

1. Signal Processing Fundamentals
   (a) Continuous and discrete signals
   (b) Fourier series (FS)
   (c) Fourier transform (FT)
   (d) Properties of the FT
   (e) The 2-dim FT
   (f) Linear systems, convolution and filtering
   (g) Energy, power and their spectral densities

2. Radio Astronomy Fundamentals
   (a) Introduction
   (b) Power, spectral power, brightness and flux density
   (c) Antenna temperature and noise
   (d) Minimum detectable antenna temperature and flux density

3. Radio Observatory and DSN Instrumentation Fundamentals
   (a) Antennas, Antenna arrays and VLBI
   (b) Time and frequency standards
   (c) Multibeam antenna systems

4. VLBI and DSN Applications to Spacecraft Navigation (Radiometric tracking techniques for deep-space navigation)
   (a) Introduction
   (b) Earth-based tracking and navigation overview
   (c) Range and Doppler tracking observables
   (d) Future directions in radiometric tracking

5. Introduction to Radar Systems (Radar fundamentals)
   (a) Introduction
   (b) Range
   (c) Doppler frequency or range rate
   (d) The Radar Equation
   (e) CW radar (FM)

Required Texts

B. Mahafza, *Introduction to Radar Analysis.* CRC Press; 1998

J. Kraus, *Radio Astronomy*, 2^{nd} ed. Cygnus-Quasar

C. Thornton, J. Borders, *Radiometric Tracking Techniques for Deep Space Navigation.* JPL Publication; 00-11. (Web Document).

Prerequisite

SC/PHYS 3250 3.0.

One term. Three credits.

Three lecture hours per week.

PHYS 4350 6.0 SPACE HARDWARE

Explores the theoretical, practical and experimental techniques needed to acquire and manipulate typical signals used in spacecraft system operations or integration and testing.

Content

The course is divided into 4 sections (2 sections each semester). The first semester covers analog and digital signals and associated test equipment. The second semester covers RF signals and the final section of the course is a software development project where students develop code to calculate antenna pointing angles necessary to track a spacecraft in orbit.

Lectures are used to review and reinforce concepts learned in the hands-on lab sessions. Students also write the Basic and Advanced Industry Canada exams to become certified amateur radio operators during the course.

Required Text

Course Kit.

Prerequisites

LE/CSE 2031 3.0 or LE/CSE 1541 3.0 prior to Fall 2013; SC/CSE 1540 3.0 or equivalent programming experience; SC/PHYS 3150 3.0; SC/PHYS 3250 3.0.

Corequisites

SC/PHYS 4330 3.0 and LE/SC/ENG 4330 3.0.

Includes three laboratory hours per week.

PHYS 4360 3.0 PAYLOAD DESIGN

Provides a comprehensive and accurate approach to the specification and detailed design of different spacecraft payloads, such as optical, microwave, communications, and planetary exploration payloads. Covers reliability analysis and its application to space systems. Design projects are integral to the course.

Content

1. Introduction
2. Payload Design and Sizing
3. Spacecraft Sensors
4. Communication Satellite Payload Design
5. Landed Payload Design
6. Reliability Analysis
7. Payload Design Project

Required Text

W.J. Larson, J.R.Wertz, *Space Mission Analysis and Design,* 3rd ed. Kluwer Academic Publishers; 2000

References

Space Mission Analysis and Design. 3rd Ed., Edited by James Wertz and Wiley Larson, Microcosm and Kluwer, ISBN 1-881883-10-8, 1999

Prerequisites

SC/PHYS 3050 3.0; SC/PHYS 3280 3.0.

PHYS 4361 3.0 SPACE MISSION DESIGN

This course covers the basic aspects of space mission design from a "blank sheet." It includes mission design structure using systems engineering approaches to the design problem. Mission deign starts with a set of mission objectives and aims to develop a viable solution for meeting these objectives given a set of technical cost and programmatic constraints. This course brings together systems engineering, mission types, objectives, technical readiness, risk mitigation, mission subsystems, and cost estimation.

Prerequisites

LE/SC/ENG 2001 3.0; LE/SC/ENG 2002 3.0 or permission of the instructor.

PHYS 4410 3.0 SPACE GEODYNAMICS

The dynamical behaviour of the Earth from space measurements. Included are the external gravity field of the Earth, orbital dynamics of artificial satellites, satellite geoid, internal figure of the Earth, rotation of the Earth and its measurement by space techniques.

Content

1. Introduction
2. Mathematical Foundation
3. Block Diagrams and Signal-Flow Graphs
4. Modeling of Physical Systems
5. State Variable Analysis
6. Stability of Linear Control Systems
7. Time-Domain Analysis of Control Systems
8. Root-Locus Technique
9. Frequency-Domain Analysis
10. Design of Control Systems

Required Text

G. Franklin, J. Powell, A. Emami-Naeini, *Feedback Control of Dynamics Systems, 5th ed*. Prentice Hall; 2006.

Prerequisites or Corequisites

LE/EATS 3020 3.0; SC/MATH 3241 3.0 or LE/CSE 3121 3.0; SC/MATH 3271 3.0

Prior to Fall 2009:
Prerequisites or corequisites: SC/EATS 3020 3.0; AS/SC/MATH 3241 3.0 or AS/SC/CSE 3121 3.0 (formerly COSC); AS/SC/MATH 3271 3.0.

Offered irregularly.

PHYS 4550 3.0 CONTROL SYSTEMS

An introduction to the analysis and design of control systems. Topics include: modeling of continuous systems, stability theory; analysis and design of feedback control systems in time and frequency domains.

Integrated with: GS/PHYS 5550 3.0

Content

1. Introduction
2. Mathematical Foundation
3. Block Diagrams and Signal-Flow Graphs
4. Modeling of Physical Systems
5. State Variable Analysis
6. Stability of Linear Control Systems
7. Time-Domain Analysis of Control Systems
8. Root-Locus Technique
9. Frequency-Domain Analysis
10. Design of Control Systems

Required Text

G. Franklin, J. Powell, A. Emami-Naeini, *Feedback Control of Dynamics Systems, 5th ed*. Prentice Hall; 2006.

Prerequisites

SC/MATH 2015 3.0; SC/MATH 2271 3.0 or LE/SC/CSE 3451 3.0.

Prior to Fall 2009:
Prerequisites: AS/SC/MATH 2015 3.0; AS/SC/MATH 2271 3.0 or AK/AS/SC/CSE 3451 3.0.

One term. Three credits.

Three lecture hours per week.

SC/BC 3030 3.0 TECHNICAL AND PROFESSIONAL WRITING

This writing-intensive course is for upper-year science students and others in related fields. Students develop confidence and competence in professional and technical writing. Focus is on communication of complex information in a clear, sensible style.

Prerequisites

At least six non-science general education credits.

Corequisite

Concurrent enrolment in at least one 3000- or 4000-level Science course (or course which is cross-listed with a Science course), or permission of the instructor.

One term. Three credits.

Three lecture hours per week.

BIOPHYSICS

BPHS 2090 3.0 CURRENT TOPICS IN BIOPHYSICS

An introduction to biophysics highlighting major themes in pure and applied biophysical research. Included is coverage of fundamental concepts in fluid mechanics. The course will present biology and physics students with an overview of the role of physics in biological research.

Required Text

No required text.

Prerequisites

SC/PHYS 1010 6.0 or SC/PHYS 1410 6.0 or SC/PHYS 1420 6.0; SC/BIOL 1000 3.0 and SC/BIOL 1001 3.0, or SC/BIOL 1410 6.0.

One term. Three credits.

BPHS 3090 3.0 BIOPHYSICS I

This course will focus on physics relevant to cellular dynamics and transport. Basic principles will include: electrodynamics (e.g., charge transport across cells, Nernst potentials), diffusion, osmosis, and wave propagation. Salient biological topics will be approached in a rigorous mathematical fashion and include those such as: cellular homeostasis, the Hodgkin-Huxley model for action potentials, molecular biology of ion channels, and molecular motors (e.g., motion in low Reynolds-number regimes). The objective of the course is to help students to integrate the knowledge gained in second and third year biology and physics courses and to use methods of physics to study biological processes.

Required Text

R. Hobbie, B. Roth, *Intermediate Physics for Medicine and Biology, 4th ed*. Springer Publications; 2007.

Prerequisites

SC/BPHS 2090 2.0; SC/PHYS 2020 3.0; SC/PHYS 2060 3.0 .

One term. Three credits.

BPHS 3900 0.0 BIOPHYSICS INTERNSHIP WORK TERM

This experiential education course reflects the work term component of the Technology Internship Program (TIP.) Qualified Honours students gain relevant work experience as an integrated complement to their academic studies, reflected in the requirements of a learning agreement and work term report. Students are required to register in this course for each for month work term, with the maximum number of work term courses being four (i.e. 16 months.) Students in this course receive assistance from the Career Centre prior to and during their internship, and are also assigned a Faculty Supervisor/Committee.

Prerequisites

Enrollment is by permission only. Criteria for permission include: 1. That students have successfully completed at least 9 BPHS or PHYS credits at the 3000 level or higher, including SC/BPHS 3090,and have a GPA of at least 5.00 in BPHS, BIOL, and PHYS courses overall; 2. That students are enrolled full-time in the Honours program prior to beginning their internship and have attended the mandatory preparatory sessions as outlined by the Career Centre; 3. That students have not been absent for more than two consecutive years as a full-time student from their Honours degree studies; 4. That upon enrolling in this course students have a minimum of 9 credits remaining toward their Honours degree and need to return as a full-time student for at least one academic term to complete their degree after completion of their final work term.

Note: This course is a pass/fail course, which does not count for degree credit. Registration in SC/BPHS 3900 0.00 provides a record on the transcript for each work term.

BPHS 4090 4.0 BIOPHYSICS II

This course will focus on applications of atomic, nuclear, and quantum physics in biology and medicine. Topics will include interactions between radiation and matter (including spectroscopy), principles of imaging and radiation therapy in medicine, and micro/nano-fluidics. An array of modern experimental techniques will also be covered, including those such as: optical tweezers, atomic force microscopy (AFM), x-ray crystallography, and nuclear magnetic resonance (NMR, MRI). Relevant signal processing strategies such as spectral analysis (e.g., Fourier transforms) and image analysis (e.g., convolutions, tomography) will be covered in detail. A regular three-hour laboratory is an integral part of the course. Students will undertake several experiments covering topics such as the following: diffusion of bio-molecules (including electro-diffusion across membranes), action potentials, absorption of radiation and fluorescence of bio-molecules, NMR spectroscopy, X-ray crystallography to determine protein structure, and bioacoustics. The objective of the course is to help students to integrate the knowledge gained in third and fourth year biology and physics courses and to use methods and techniques of physics to study biological processes. The course is designed to be a capstone to the Biophysics Program.

Prerequisites

SC/BPHS 3090 3.0; SC/PHYS 3040 6.0.

One term. Four credits.

CHEMISTRY

CHEM 1000 3.0 CHEMICAL STRUCTURE

Introduction to chemistry with emphasis on physical and electronic structure of matter, including gases, liquids and solids. Topics include behaviour of gases; thermochemistry; atomic structure and periodic table; chemical bonding and architecture; structure of liquids and solids; frontiers of chemistry.

Required Text

R. Petrucci, W. Harwood, G. Herring, J. Madura, *General Chemistry: Principles and Modern Application, 9th ed.* Prentice Hall; 2006

Prerequisites

OAC chemistry, 12U chemistry or SC/CHEM 1500 4.0 or equivalent.

Course Credit Exclusion

SC/CHEM 1000 6.0, SC/CHEM 1010 6.0.

One term. Three credits.

Two and one-half lecture hours per week, one tutorial hour per week, six three-hour laboratory sessions.

CHEM 1001 3.0 CHEMICAL DYNAMICS

This course complements SC/CHEM 1000 3.00 - with emphasis on chemical change and equilibrium. Topics include chemical kinetics; chemical equilibrium; entropy and free energy as driving forces for chemical change; electrochemistry; frontiers in chemistry.

Required Text

R. Petrucci, W. Harwood, G. Herring, J. Madura, *General Chemistry: Principles and Modern Application, 9th ed.* Prentice Hall; 2006

Prerequisites

OAC chemistry, 12U chemistry or SC/CHEM 1500 4.0 or equivalent.

Course Credit Exclusion

SC/CHEM 1000 6.0, SC/CHEM 1010 6.0

One term. Three credits.

Two and one-half lecture hours per week, one tutorial hour per week, six three-hour laboratory sessions.

CSE 1541 3.0 COMPUTING FOR THE PHYSICAL SCIENCES

An introduction to scientific computing using an integrated computing and visualization platform. Elements of procedural programming such as: control structures, data types, program modules. Visualization in two and three dimensions. Applications to numerical computation and simulations relevant to the physical sciences.

Required Text

TBA

Prerequisites

SC/MATH 1013 3.00 or equivalent.

Corequisites

SC/PHYS 1010 6.00 or SC/PHYS 1410 6.00 or SC/PHYS 1420 6.00; and SC/MATH 1021 3.00 or SC/MATH 1025 3.00.

Course Credit Exclusions

LE/SC/CSE 1560 3.00, LE/SC/CSE1570 3.00.

One Term. Three credits.

Twice weekly meetings, each consisting of one lecture hour followed by a one and a half hour laboratory session.

CSE 2501 1.0 FORTRAN AND SCIENTIFIC COMPUTING

Covers computer-base problem solving in a variety of scientific and engineering settings. Introduces the FORTRAN programming language and its interface with scientific libraries. Applications are drawn mainly from scientific areas such as numerical methods, processing experimental data, simulation and data visualization.

Required Text

TBA

Prerequisites

One of LE/CSE 1020 3.00, LE/CSE 1530 3.00

Prior to Summer 2013:
Prerequisites: One of SC/CSE 1020 3.00, SC/CSE 1530 3.00.
Prior to Fall 2009:
Prerequisites: One of AK/AS/SC/CSE 1020 3.00, AK/AS/SC/COSC 1020 3.00, AK/AS/SC/CSE 1530 3.00, AK/AS/SC/COSC 1530 3.00.

Course credit exclusion

SC/COSC 2501 1.0.

One term. One credit.

EARTH AND SPACE SCIENCE AND ENGINEERING

EATS 1010 3.0 THE DYNAMIC EARTH AND SPACE GEODESY

An overview of modern geophysics: origin of the Earth, impact cratering, internal structure and rheology, earthquakes, plate tectonics, geomagnetism. Space geodetic positioning techniques such as VLBI, SLR and GPS are introduced as means of detecting and monitoring tectonic movements.

Required Text

TBA

Prerequisites

12U Calculus and Vectors or 12U Advanced Functions and Introductory Calculus (pre 2007 version) or equivalent, or SC/MATH 1515 3.0; 12U Physics or SC/PHYS 1510 4.0.

Course Credit Exclusion

SC/EATS 1010 6.0, SC/NATS 1750 6.0.

Prior to Fall 2009:
Prerequisites: 12U calculus and vectors or 12U advanced functions and introductory calculus (pre 2007 version) or equivalent, or AS/SC/MATH 1515 3.0; 12U physics or SC/PHYS 1510 4.0.
Course Credit Exclusion: SC/EATS 1010 6.0, SC/NATS 1750 6.0.

One term. Three credits.

EATS 1011 3.0 INTRODUCTION TO ATMOSPHERIC SCIENCE

The origin, composition and vertical structure of the Earth's atmosphere and those of other planets. The present global atmospheric circulation. Weather systems, measurements and weather maps; atmospheric chemistry; the ozone layer and atmospheric pollution.

Required Text

TBA

Prerequisites

12U Calculus and Vectors or 12U Advanced Functions and Introductory Calculus (pre 2007 version) or equivalent; SC/MATH 1515 3.00; 12U Physics or SC/PHYS 1510 4.00.
Course Credit Exclusion

SC/EATS 1010 6.0, SC/NATS 1750 6.0.

Prior to Fall 2009:
Prerequisites: 12U Calculus and vectors or 12U advanced functions and introductory calculus (pre 2007 version) or equivalent; AS/SC/MATH 1515 3.0; 12U physics or SC/PHYS 1510 4.0.
Course Credit Exclusion: SC/EATS 1010 6.0, SC/NATS 1750 6.0.

One term. Three credits.

Three lecture hours per week, five three-hour laboratory sessions.

EATS 2030 3.0 GEOPHYSICS AND SPACE SCIENCE

Seismic waves, earthquake fault plane solutions, tectonics on a sphere, geochronology, paleomagnetism, Earth's magnetic field, its origin and deformation by solar winds. VLBI measurements of fluctuations of Earth rotation, gravitational perturbations of satellite orbits, planetary exploration and communications issues.

Required Text

TBA

Prerequisites

SC/MATH 1014 3.0; SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0.

Prior to Fall 2009:
Prerequisites: AS/SC/MATH 1014 3.0; SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0.

One term. Three credits.

Three lecture hours and a one-hour computer laboratory.

EATS 2470 3.0 INTRODUCTION TO CONTINUUM MECHANICS

Introductory tensor algebra and calculus. Stress and strain analysis. Symmetry of stress tensor, equilibrium conditions. Lagrangian and Eulerian descriptions of strain. Physical interpretation of stress, strain and strain rate tensors. Conservation laws in continua. Consistency and compatibility considerations. Constitutive relations.

Required Text

TBA

Prerequisites

LE/CSE 1540 3.0; SC/MATH 1025 3.0; SC/MATH 2015 3.0; SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0.

Prior to Summer 2013:
Prerequisites: SC/CSE 1540 3.00; SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00.
Prior to Fall 2009:
Prerequisites: AK/AS/SC/CSE 1540 3.0 (formerly COSC); AS/SC/MATH 1025 3.0; AS/SC/MATH 2015 3.0; SC/PHYS 1010 6.0, or a minimum grade of C in SC/PHYS 1410 6.0.

Course Credit Exclusion

SC/EATS 2470 4.0.

One term. Three credits.

Two lecture hours and a tutorial or problems laboratory session.

EATS 4610 3.0 GLOBAL POSITIONING SYSTEMS

Positioning by space vehicles. Coordinate systems and transformations. GPS, GLONASS, GALILEO, Satellite Laser Ranging, Very Long Baseline Interferometry. Positioning of moving vehicles and platforms: marine, land, airborne and space vehicles. GPS/INS integration. Real time kinematic applications.

Required Text

TBA

Prerequisites

LE/EATS 3020 3.00; LE/EATS 3610 4.00 or LE/ENG 3110 4.00; LE/EATS 3620 4.00 or LE/ENG 3120 4.00; or permission of the course director.

Prior to Summer 2013:
Prerequisites: SC/EATS 3020 3.00; SC/EATS 3610 4.00 or SC/ENG 3110 4.00; SC/EATS 3620 4.00 or SC/ENG 3120 4.00; or permission of the course director.

One term. Three credits.

Three lecture hours weekly and three hours of laboratory exercises every other week.

MATHEMATICS & STATISTICS

MATH 1013 3.0 APPLIED CALCULUS I

Introduction to the theory and applications of both differential and integral calculus. Limits. Derivatives of algebraic and trigonometric functions. Riemann sums, definite integrals and the Fundamental Theorem of Calculus. Logarithms and exponentials, Extreme value problems, Related rates, Areas and Volumes.

Required Text

TBA

Prerequisites

SC/MATH 1515 3.0 or SC/MATH 1520 3.0, or a high school calculus course.

Course Credit Exclusion

SC/MATH 1000 3.0, SC/MATH 1300 3.0, SC/MATH 1505 6.0, SC/MATH 1513 6.0, SC/MATH 1530 3.0, SC/MATH 1550 6.0, GL/MATH/MODR 1930 3.0, AP/ECON 1530 3.0.

Prior to Fall 2009:

Prerequisites: AS/SC/MATH 1515 3.0 or AS/SC/MATH 1520 3.0, or a high school calculus course.
Course credit exclusions: AS/SC/MATH 1000 3.00, AK/AS/SC/MATH 1300 3.00, AS/SC/MATH 1505 6.00, AS/SC/MATH 1513 6.00, AS/MATH 1530 3.00, AK/AS/MATH 1550 6.00, GL/MATH/MODR 1930 3.00, AS/ECON 1530 3.00.

One term. Three credits.

Three lecture hours per week.

MATH 1014 3.0 APPLIED CALCULUS II

Calculus in Polar Coordinates. Techniques of Integration. Indeterminate Forms. Improper Integrals. Sequences, infinite series and power series. Approximations. Introduction to ordinary differential equations.

Required Text

TBA

Prerequisites

One of SC/MATH 1000 3.0, SC/MATH 1013 3.0, SC/MATH 1300 3.0, or SC/MATH 1513 6.0; for non-science students only, six credits from SC/MATH 1530 3.0 and SC/MATH 1540 3.0, SC/MATH 1550 6.0, AP/ECON 1530 3.0 and AP/ECON 1540 3.0.

Course Credit Exclusion

SC/MATH 1010 3.0, SC/MATH 1310 3.0, SC/MATH 1505 6.0, GL/MATH/MODR 1940 3.0.

Prior to Fall 2009:

Prerequisites: One of AS/SC/MATH 1000 3.0, AS/SC/MATH 1013 3.0, AK/AS/SC/MATH 1300 3.0, or AS/SC/MATH 1513 6.0; for non-science students only, six credits from AS/MATH 1530 3.0 and AS/MATH 1540 3.0, AK/AS/MATH 1550 6.0, AS/ECON 1530 3.0 and AS/ECON 1540 3.0.
Course credit exclusions: AS/SC/MATH 1010 3.00, AK/AS/SC/MATH 1310 3.00, AS/SC/MATH 1505 6.00, GL/MATH/MODR 1940 3.00.

One term. Three credits.

Three lecture hours per week.

MATH 1025 3.0 APPLIED LINEAR ALGEBRA

Topics include spherical and cylindrical coordinates in Euclidean 3-space, general matrix algebra, determinants, vector space concepts for Euclidean n-space (e.g. linear dependence and independence, basis, dimension, linear transformations etc.), an introduction to eigenvalues and eigenvectors.

Required Text

TBA

Prerequisites

One 12U or OAC mathematics course or equivalent.

Course Credit Exclusion

SC/MATH 1021 3.0, SC/MATH 2021 3.0, SC/MATH 2221 3.0, GL/MATH/MODR 2650 3.0.

Prior to Fall 2009:

Course credit exclusions: AK/AS/SC/MATH 1021 3.0, AS/SC/MATH 2021 3.0, AK/AS/SC/MATH 2221 3.0, GL/MATH/MODR 2650 3.0.

One term. Three credits.

Two and one-half lecture hours per week. One Tutorial hour per week. Six three hour laboratory sessions.

MATH 2015 3.0 APPLIED MULTIVARIATE AND VECTOR CALCULUS

Topics covered include partial derivatives; grad, div, curl and Laplacian operators; line and surface integrals; theorems of Gauss and Stokes; double and triple integrals in various coordinate systems; extrema and Taylor series for multivariate functions.

Required Text

TBA

Prerequisites

One of SC/MATH 1010 3.0, SC/MATH 1014 3.0, SC/MATH 1310 3.0; or SC/MATH 1505 6.0 plus permission of the course coordinator.

Course Credit Exclusion

SC/MATH 2010 3.0, SC/MATH 2310 3.0, GL/MATH/MODR 2670 3.0, GL/MATH 3200 3.0.

Prior to Fall 2009:

Prerequisite: One of AS/SC/MATH 1010 3.0, AS/SC/MATH 1014 3.0, AK/AS/SC/MATH 1310 3.0; or AS/SC/MATH 1505 6.0 plus permission of the course coordinator.
Course credit exclusions: AS/SC/MATH 2010 3.00, AK/AS/SC/MATH 2310 3.00, GL/MATH/MODR 2670 3.00, GL/MATH 3200 3.00.

One term. Three credits.

Three lecture hours per week.

MATH 2271 3.0 DIFFERENTIAL EQUATIONS FOR SCIENTISTS AND ENGINEERS

Introduction to ordinary and partial differential equations, including their classification, boundary conditions, and methods of solution. Equations, methods, and solutions relevant to science and engineering are emphasized, and exploration is encouraged with the aid of software.

Required Text

TBA

Prerequisites

One of SC/MATH 2010 3.0, SC/MATH 2015 3.0, SC/MATH 2310 3.0 or equivalent; one of SC/MATH 1025 3.0, SC/MATH 2022 3.0, SC/MATH 2222 3.0 or equivalent.

Course Credit Exclusion

SC/MATH 2270 3.0, GL/MATH 3400 3.0.

Prior to Fall 2009:

Prerequisites: One of AS/SC/MATH 2010 3.0, AS/SC/MATH 2015 3.0, AS/SC/MATH 2310 3.0 or equivalent; one of AS/SC/MATH 1025 3.0, AS/SC/MATH 2022 3.0, AS/SC/MATH 2222 3.0 or equivalent.
Course Credit Exclusions: AS/SC/MATH 2270 3.00, GL/MATH 3400 3.00.

One term. Three credits.

Three lecture hours per week.

NOTES

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(*Sabbatical Jul. 2014 - Jun. 2015)

RESEARCH FIELDS

AA	Astronomy & Astrophysics	CCM	Chemical & Condensed Matter Physics
AMO	Atomic, Molecular & Optical Physics	EASE	Earth, Atmospheric, Space & Engineering Physics
B	Biological Physics	HEP	High Energy & Particle Physics