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1 Purpose of the Handbook

Entry into university is accompanied by a deluge of information, much of it electronic. Everything you need to know is probably on line, but finding it—and finding it in time for it to do you good—is another matter. This handbook aims to give you a concise, readable introduction to the Carleton University Physics Department and the programs and resources you’ll need to know about during your undergraduate physics career. Much more information is available on the Physics Department web site, http://www.physics.carleton.ca; direct links to the relevant content will be provided throughout.

This handbook also attempts to present some of the informal advice to physics students that doesn’t find a place in official university documents. We hope you find this handbook useful. It was originally prepared by Prof. Heather Logan. Comments and additions are welcome and should be directed, this year, to Prof. Tong Xu, (undergrad-advisor@physics.carleton.ca).

An electronic copy of this handbook can be downloaded from http://www.physics.carleton.ca/current-undergraduate_students.

2 Introduction to the Physics Department

The Physics Department is housed in Herzberg Laboratories, often abbreviated HP. The department office is in 3302 HP, on the 3rd floor of the central “research wing” of Herzberg. Physics faculty offices occupy the 3rd floor of the research wing and the 2nd floor INCO Annex, reachable from the back of the research wing. The physics teaching labs are located on the 3rd and 4th floors of the “teaching wing” on the southeast side of the building. The Carleton University Physics Society (undergrad physics club) has its lounge in 3413 HP, on the 3rd floor of the “new section” of the INCO wing of the building (so named because it houses the Dean of Science’s office on the 3rd floor). Physics classes are centrally scheduled and therefore are held in classrooms scattered around campus; for a campus map see http://www2.carleton.ca/campus.

The main channel of communication between the physics department and you (and more generally between Carleton University and you) will be your Carleton Connect or CMail email account. You will be held responsible for having received all notices sent to that account, so check it frequently! If you prefer to read your email on a different account, it’s easy to set up your Carleton email account to forward messages to the address of your choice. When emailing professors or administrators, it’s generally a good idea to do so from your Carleton email account—this provides a verification of your identity. Requests for private information (your marks, etc.) will only be responded to if sent from your Carleton email account.

Your first point of contact to the department will probably be our Undergrad Administrator, Joanne Martin:

Undergraduate Administrator:
Joanne Martin
3302 HP
(613) 520-4320
joanne_martin@carleton.ca

You should see Joanne for issues related to course registration, permissions and overrides, academic audits, and advice on enrolment.
For broader advice on your undergraduate physics degree program and which courses to take year-by-year, you should talk to our Associate Chair for Undergraduate Studies (and Undergraduate Advisor), Prof. Tong Xu:

**Undergraduate Advisor:**
Prof. Tong Xu  
3318 HP  
(613) 520-2600 ext. 8794  
undergrad-advisor@physics.carleton.ca

Extensive web-based information for current undergrads is located at [http://www.physics.carleton.ca/current-undergraduate-students](http://www.physics.carleton.ca/current-undergraduate-students). This information is very important because of the need to satisfy prerequisite requirements as you progress year by year through your degree program.

### 3 Physics Degree Programs

The Physics Department offers the following degree programs:

- B.Sc. Double Honours Math & Physics
- B.Eng. Engineering Physics
- B.Sc. Honours Experimental Physics
- B.Sc. Honours Theoretical Physics
- B.Sc. Honours Applied Physics (optional Minor in Business available)
- B.Sc. Combined Honours Biology & Physics
- B.Sc. Combined Honours Chemistry & Physics
- B.Sc. Major in Physics

The B.Sc. Double Honours Math & Physics and B.Eng. Engineering Physics programs are elite programs requiring 21.5 credits (compared to the usual 20.0 credits required to graduate) and require a higher minimum entry average than other honours programs. Engineering Physics, offered in collaboration with the Department of Electronics in the Faculty of Engineering, is a B.Eng. program. It is accredited by the Canadian Engineering Accreditation Board, and therefore its graduates are eligible to apply for P.Eng. (Professional Engineer) certification after sufficient work experience.

The Honours B.Sc. programs offer streams with an emphasis in Experimental Physics, Theoretical Physics, or Applied Physics, as well as two combined programs, with Biology and with Chemistry. All the Honours B.Sc. programs (including Math & Physics) include a fourth-year honours project, providing you with research experience under the supervision of a faculty member. Joint programs allow the honours project to be undertaken in either of the involved departments. There is a specially-designed Minor in Business available for Applied Physics students.
The four-year Major program in Physics allows room in your schedule to take a minor in another subject area such as computer science or business. The honours project is not available in this program.

Information for each program, including the list of required courses, can be found at http://www.physics.carleton.ca/current-undergraduate-students/program-information. It is possible to change your program; for information on this you should contact Joanne Martin (the Undergraduate Administrator; contact information in Sec. 2). Be aware that if you change your program, your set of required courses will change.

4 Courses and Timetables

All students in Physics B.Sc. or Engineering Physics programs should take PHYS 1001 and 1002 in their first year, unless prevented from enrolling by the lack of a high-school prerequisite. In that case, you should take PHYS 1007 and 1008 if you’re missing grade 12 Calculus. Note that PHYS 1007 and 1008 must be passed with a cumulative grade of B− or better in order to proceed to second-year physics classes. Note also that some excellent physics students have come into our programs through the PHYS 1007/1008 route; however, your best preparation for the rest of the physics program will come from PHYS 1001/1002, with PHYS 1003/1004 as a second choice. PHYS 1001 and 1002 are specialist courses for physics students with more advanced material and smaller class sizes than the others. They also provide the chance to get to know your fellow physics students.

Figuring out which courses to take in each year of your program can be tricky. For this reason, we have provided detailed instructions for each of our physics programs on which courses you should take in each year. Details for each program can be found at http://www.physics.carleton.ca/current-undergraduate-students/program-information.

We strongly recommend that you follow the prescribed order of courses! Some of these courses—especially physics, math, and computing courses—are prerequisites for later courses, so changing the sequence of your courses is likely to cause you trouble later on when you try to enrol in a course and find you don’t have the prerequisite. It is particularly important to proceed through the math courses as required. For that reason, if you want to deviate from the recommended course sequence you should discuss your plan with the Undergrad Advisor (Prof. Tong Xu; contact information in Sec. 2). We have also done our best to schedule the courses in each year of your program to avoid time conflicts between required courses within a given year. This is not always possible to achieve for courses that students usually take in different years. Taking courses in a different year than recommended may therefore lead to time conflicts between your courses.

You should become familiar with your specific program requirements as described in Sec. 3; however, here is a general sense of what your program will be like.

First year: In first year university, much of your schedule will be required courses, which are prerequisites to upper year courses. These will give you the basics that you need in order to continue on in the program as well as some breadth of study into subjects other than your major. Your timetable will contain physics, math, an experimental science (chemistry, biology or earth sciences), computer science (programming), and an arts or social science elective (or NSCI 1000).

Second year: Second year is when the different physics programs begin to develop their individual flavour. Almost all students will take physics courses in optics, Electricity and Magnetism, Thermal Physics, and modern physics, as well as calculus and mathematical methods. Students in the Theory stream as well as Math & Physics pursue additional mathematics courses. Students in the
Experimental stream as well as Applied Physics take specialized courses in electronics. Engineering Physics students take a number of electronics and computer science courses. Biology & Physics students pursue animal physiology, biochemistry and genetics while Chemistry & Physics students learn about physical and organic chemistry. Students in the Physics Major program will typically begin the courses for their minor. Note that all programs require students to take MATH 3705 in their second year (it is a prerequisite for PHYS 3308 and 3807, for instance).

**Third year:** Your third year will consist mostly of Physics courses, with electromagnetism, quantum mechanics, modern physics, advanced dynamics, mathematical physics, and thermodynamics courses, as well as an advanced laboratory course. For students in Engineering Physics, some of these courses are replaced with courses in advanced electronics. Students in combined programs will also take courses in the partner department as appropriate—math, biology, or chemistry. Note half of the programs require students to take PHYS 4409 in third year.

Third year is perhaps the most intense year of the program: where previously you will have taken only a couple of physics courses per year, your schedule will now consist mostly of physics. This tends to require some adjustment, and is worth planning for in your outside activities (e.g., it is highly recommended to limit your employment hours outside the department if at all possible).

**Fourth year:** Your fourth year rounds out the program with an independent research project under the supervision of a professor (for details, see the Fourth-Year Honours Project description in Sec. 11). Fourth year students should consult the department website in late summer so you are prepared to secure your fourth year honors project (PHYS 4907, 4908 or 4909) early in September. Students in joint programs may do their project in either Physics or the partner department. Students in Engineering Physics undertake a team-based design project through the Electronics Department. Physics courses consist of quantum mechanics as well as advanced physics electives. Students in Applied Physics, Experimental Physics, and Engineering Physics will take an additional advanced laboratory credit, and students in joint programs take additional advanced courses in the partner department. Be aware that fourth-year course options might be limited based on demand. The set of upper-year courses that is being offered during the 2014/2015 academic year is PHYS 4007, 4008, 4208, 4409, 4508, 4602, 4608, 4707, 4708 and 4807. Official course descriptions can be found at [http://calendar.carleton.ca/undergrad/courses/PHYS/](http://calendar.carleton.ca/undergrad/courses/PHYS/).

**5 Safety on Campus**

The Physics Department actively follows the University Health and Safety procedures and all government regulations. When working in the laboratories associated with your courses, you will find that the lab supervisors and technical staff all emphasize safe procedures. As you progress through your program, you may work in a research lab; your faculty supervisor along with the other researchers involved will emphasize proper safety training and procedures. The Carleton Environmental Health and Safety website has lots of good information, at [http://www.carleton.ca/ehs/programs/](http://www.carleton.ca/ehs/programs/).

For general information on personal safety and campus safety programs, see [http://www5.carleton.ca/safety/programs/](http://www5.carleton.ca/safety/programs/). Particularly noteworthy is the Work After Hours program, a free service for any member of the campus community working during the quiet hours of the evening, weekends, and statutory holidays. When you plan to work after hours, call the Department of University Safety at (613) 520-3612. They will ask for your name, exact location, and telephone number for your workplace, as well as your estimated time of departure. Safety officers can patrol your worksite and/or escort you to your vehicle at your request. You have to
register each time you want to use the service. More information is at [http://www5.carleton.ca/safety/programs/protect-yourself/working-after-hours-program/](http://www5.carleton.ca/safety/programs/protect-yourself/working-after-hours-program/). General campus safety tips can be found at [http://www5.carleton.ca/safety/resources/safety-tips/](http://www5.carleton.ca/safety/resources/safety-tips/), where you will find good advice such as the following:

- If you see someone acting suspiciously, call the campus security emergency number (4444 from a campus phone or 613-520-4444 from a cellphone) or use one of the emergency assistance phones.
- Try to work with another person if you’re planning to stay past regular hours.
- When working alone in an office, lock your door. Inform campus security at (613) 520-3612 of where you’re working and when you plan to leave.
- Report all broken locks, windows, lights, and doors to the Maintenance Control Centre at (613) 520-3668.
- If you’re travelling after 9 p.m. on OC Transpo, your driver can drop you off at a spot closer to your destination along the bus route. For more information, see OC Transpo’s travel tips and safety page at [http://www.octranspo1.com/safe-travels/](http://www.octranspo1.com/safe-travels/).
- Avoid walking in isolated areas at night. There are designated safe pathways throughout campus that are well-lit for your safety.

Call 4444 (campus phones) or (613) 520-4444 (cellphones) in case of all on-campus emergencies and security concerns. The off-campus emergency services number is 911.

### 6 Carleton University Physics Society

The Carleton University Physics Society (CPS) is designed as a social network and education tool for physics undergrads, graduates, faculty, and physics enthusiasts in general. For a $10 membership fee you will get an official CPS membership card, discounts on CPS merchandise like coffee mugs and shirts, and access to the CPS mailing list that will keep you up to date on all events.

CPS maintains a lounge in 3413 in the new section of Herzberg, where you can relax on the couch, read the CPS collection of textbooks, refrigerate or microwave your lunch, check your email on the PC, and study or socialize with fellow physics students.

The Society plans many social events throughout the year including movie nights, board game nights, soccer, and hockey games. In the past, the Physics Society organized a road trip to Sudbury to visit the world famous Sudbury Neutrino Observatory located a mile underground. Other trips of academic interest can be planned.

**CU Physics Society Contact Information:**

Email: physsoc@physics.carleton.ca  
Phone: (613) 520-2600 ext. 7534  
Lounge: 3413 HP  
Web page: [https://www.physics.carleton.ca/society](https://www.physics.carleton.ca/society)

**CU Physics Society 2016–2017 Executive:**  
President: Waqar Muhammad
7 Canadian Association of Physicists

The Canadian Association of Physicists (CAP) is a broadly-based national network of physicists working in Canadian educational, industrial, and research settings. They are a strong and effective advocacy group for support of, and excellence in, physics research and education. They represent the voice of Canadian physicists to government, granting agencies, and many international scientific societies. They sponsor a multitude of events and activities promoting Canadian physics and physicists, including the CAP’s annual Congress and national physics journal *Physics in Canada*. Their website, at [http://www.cap.ca](http://www.cap.ca), is a key information resource for people pursuing physics education and careers. Membership in the CAP is free for undergraduate physics students at Canadian universities and gets you a subscription to *Physics in Canada*, a reduced registration fee for the annual Congress, reduced subscription rates to a variety of scientific journals, and other benefits; see the CAP website for details.

**CAP Lecture:** During each Winter term the CAP sponsors a visit to the Department by a well-known physicist from a Canadian university to deliver a talk on his or her research. The CAP Lecture is aimed specifically at undergrad students and is chosen with input from the CU Physics Society. Past CAP lectures at Carleton have included the Physics of Flight, Quantum Computing, and How Cells Measure Space and Time. Generally held in March.

**CAP University Physics Prize Examination:** This is an annual nation-wide competitive examination sponsored by the CAP, based on general knowledge in physics and open to all physics undergrads at Canadian universities. The exam is made up of questions chosen from submissions by university faculty across the country. CAP provides a first prize, the Lloyd G. Elliott Prize, of $500, a second prize of $250, and a third prize of $125. In addition, the winner of the first prize receives an all-expenses-paid trip to the CAP’s Annual Congress to receive his/her prize at the banquet. The Examination is generally held in early February. For details, past exams, and past winners, see [http://www.cap.ca/en/activities/medals-and-awards/prizes-students/university-prize-exam](http://www.cap.ca/en/activities/medals-and-awards/prizes-students/university-prize-exam).

**Canadian Undergraduate Physics Conference:** This conference is organized by Canadian undergraduate physics students and is held over a 4-day period during Fall term at a Canadian university. The papers presented are by invited speakers and by students—the CUPC is a great opportunity to present the results of your research done in a summer internship, fourth-year honours project, or co-op placement, as well as an opportunity for undergrad physics students from across the country to meet and discuss topics of interest. The CU Physics Society puts in requests for expenses of delegates to be partly covered by the Physics Department and the Faculty of Science (and the Faculty of Engineering and Design when Engineering Physics students participate); funding is more likely to be granted for students who are giving a talk or presenting a poster. It is critical to get organized early in the term, both as an individual and as a group. For more information, see [http://cupc.ca](http://cupc.ca)
8 Survival Guide for Physics Courses

This section is adapted from the Trent University Department of Physics and Astronomy Undergraduate Handbook (2007-2008).

Physics is the description of physical aspects of nature in the language of mathematics. There are three major steps in this process: (1) collecting the experimental data needed to build and test our models of the world, (2) developing a relatively few basic models (that can be described mathematically) that are at the base of a large number of natural phenomena, and (3) learning how to recognize which of these models apply to a given phenomenon and developing a mathematical description for it, beginning with the basic concepts. We are not born with the skills to see and describe the physical world in mathematical terms, and to pass on this information to others. All components of the physics curriculum are designed to help you develop and improve these skills.

1. Attend all lectures and tutorials. The main importance of lectures and tutorials is not the transfer of information, which can be obtained from your textbook or on the internet. Rather, it is to provide you with an understanding of the basic physical concepts, to develop your “physical intuition” by establishing the physical connection between the equations and reality, and to help you learn approaches for developing mathematical descriptions of phenomena starting from basic physics concepts. The instructor has spent years developing his or her ability in these areas, and the interaction with the instructor is a crucial “apprenticeship program” for passing on these skills.

2. Complete all labs and submit all reports. Labs have four main purposes: to help you relate the theoretical concepts to physical reality; to give you experience in using laboratory equipment and in collecting and analyzing experimental data in an orderly way; to develop the skills to work as part of a team; and to provide training in writing technical reports which are a crucial part of most physics-related jobs.

3. Do all assigned problems. A wise physicist once said that physics knowledge doesn’t enter through your eyes or ears; rather, it travels up your pencil, through your arm, and into your brain. The assigned physics problems are chosen to improve your skills. As with any foreign language, the ability to use the physics concepts and mathematics in this way depends as much on practice as on learning the rules of “grammar.” “Studying physics” means primarily doing more problems, not re-reading the text or lecture notes.

   Corollary 1. Working with other students is an excellent way to develop your understanding and analytical skills. However, you should always work through your final solutions independently. This is the only way to be sure that you really know the work. Identify each physical principle you use in solving a problem (e.g., conservation of angular momentum) and know why it applied so you will recognize when to use it again.

   Corollary 2. Show clearly the logic of your solution, and define all variables. Most of the marks are for your reasoning, not for the final numerical answer.

4. Always find out where you went wrong in assignments, and learn how to avoid the mistake in the future. The main purpose of tests and of assignments (after practice) is to show you what you do not understand. This is clearly where you should concentrate your study efforts.

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1Prof. Roderick Reid, Physics Department, University of California at Davis.
5. Do not waste time memorizing more equations than absolutely necessary. The intrinsic beauty of physics is that you can explain many complex results in terms of a few fundamental concepts. Therefore, you should concentrate on learning only the most basic equations and how to use them to derive more complicated results, since this will be what is primarily required on tests and in the workplace. Your analytical skills are the important ones, not the ability to memorize formulae and substitute numbers. Learn to “see” what the math means. For example, \( \vec{F} = m\vec{a} \) means that if you push with net force \( \vec{F} \) on a body of mass \( m \), it accelerates away with an acceleration \( \vec{a} \), and the acceleration is smaller if the mass is larger. The vector signs tell you that the force and the acceleration are in the same direction. If you cannot see what the math means, you usually don’t understand the physics.

6. Do not be afraid to say that you do not understand. This is exactly the time when you are closest to taking control of the material, since you have identified where your difficulty lies. Persevere. Have someone explain it to you one more time from a different perspective. And remember, if you are having trouble with a point, your classmates probably are too. This is particularly important for fundamental (“simple”) topics, since they form the foundation for more advanced work.

7. Hand everything in, and on time. The importance of this cannot be overstated. Even if you have not completed an assignment, hand it in. Some marks are better than no marks, and making an assignment late by one day to improve the grade by 10% makes no sense if you lose 20% for lateness. Check the course outline at the beginning of term for the specifics of each instructor’s grading scheme. If the policies for late assignments are not clear, ask.

8. Be aware of what each component of the course is worth, and budget your time accordingly. Note that these are time-management skills required for any job, not just physics skills.

9. Studying for tests and the final exam. The best way to study is to start by making sure that you can do all the questions assigned throughout the course, using just the most basic formulae, since these problems have been chosen to cover the most important areas of the course.

10. If you are sick. If you miss an assignment, test or final exam because of illness or a similar good excuse, you must obtain a dated note, preferably on letterhead, from some reliable source (e.g., doctor) stating that you were unable to fulfill your obligations; otherwise you will lose marks for that course component. Carleton University’s policy on deferred final exams is very strict and you should familiarize yourself with it well ahead of time, just in case. If you know that an attendance problem is coming up, contact the instructor beforehand—accommodations for late assignments due to illness can sometimes be made, but not if the instructor has already posted solutions. If you miss a lab for a good reason, contact the lab instructor as soon as possible to arrange a time to do the lab. For first-year courses a special period toward the end of term is generally set aside for make-up labs or tutorial tests.

11. Take some responsibility for the teaching of the course. If you have an idea that could improve the course, pass it on to the instructors. They want the course to be as good as possible, too.
9 Academic Integrity

As noted above, you are encouraged to discuss your coursework with other students. However, the work you turn in must be your own. Proper citation must be made to give credit to work you have consulted and used. These are aspects of academic integrity. Useful information on academic integrity issues and a link to the University’s academic integrity policy can be found at http://www2.carleton.ca/sasc/advisingcentre/academic-integrity/. For Physics Department policies, please see http://www.physics.carleton.ca/current-undergraduate-students/academic-policies. This link contains information regarding plagiarism, academic accommodation for disabilities, pregnancy, or religious obligations, and the Department’s privacy policy. It is your responsibility to read these policies.

10 Resources for Help in Physics

For each of your courses, the instructor will announce his or her office hours. This is where to go if you have questions about the homework assignments, lecture material, exams, etc. If your schedule prevents you from attending the announced office hours, you can contact the instructor (preferred contact information should be on the course outline) and he or she should be happy to set up an appointment to see you.

You can also get help from upper-year physics students. The CU Physics Society is an excellent resource for making connections with more advanced physics students; see Sec. 6 for details. Some courses (e.g., PHYS 1004 and PHYS 1007) also provide their own drop-in help sessions run by TAs; information will be provided by your instructor.

More general help can be obtained from the Science Student Success Centre (SSSC) in 3431 HP. The SSSC mentors science students and runs workshops on topics such as time management, exam strategies and study skills. The goal is to help students develop learning strategies and good study habits to ease the transition from high school to university. For more information, see http://sssc.carleton.ca/.

11 Undergrad Research Opportunities

“[I]n my senior year, I was offered a research assistantship, and for the first time, I worked on a problem where the answer wasn’t known. And I got hooked. [...] I would say the most influential thing was that participation in research as an undergraduate.” Prof. Arthur Bienenstock, President of the American Physical Society (2008), on how he became interested in physics. APS News, January 2008.

As a Carleton Physics student, you too can have the opportunity to work on problems where the answer isn’t known. All these research opportunities require some advance planning, e.g., for preparing applications or lining up a supervisor, so they are worth a bit of forethought.

Fourth-Year Honours Project: These are advanced projects of an experimental or theoretical nature with an orientation towards research, and are a required component of all Honours programs. Students in joint programs (Biology & Physics, Chemistry & Physics, and Double Honours Math & Physics) can choose to do their fourth-year project in either one of the involved departments. Generally your program will require PHYS 4909 (full-year project) or PHYS 4907 or 4908 (half-year project) plus an additional fourth-year physics course.
The project involves a minimum of six hours laboratory or private study a week under the supervision of a faculty member. You’ll submit a mid-term progress report half way through the project and a written final report at the end. All students also present an oral report on their project at the end of the project term, giving the department as a whole an opportunity to learn about the research projects. Past fourth-year project reports are archived in the department office.

It’s a good idea to start thinking about your honours project over the summer before the start of your fourth year, or even at the end of your third year. Start by reading over the projects on offer from various faculty members. A list of these (and additional honours project information) can be found on the honours projects web page linked from http://www.physics.carleton.ca/courses/course_material (scroll down to “PHYS 4909 Honours Project”).

You will need to line up a supervisor yourself. Do this by contacting the professor(s) whose project descriptions interest you; feel free to “shop around” a little and talk to more than one professor. Carleton students can also be supervised by University of Ottawa faculty, and vice versa. This must be done as early in the term as possible: getting a late start on your honours project is not a situation you want to put yourself in. Once you’ve chosen a supervisor, make sure that the supervisor and the honours project coordinator both know about your choice. The honours project coordinator is Prof. Kevin Graham:

Honours Projects Coordinator:
Prof. Kevin Graham
3322 HP
(613) 520-2600 ext. 4373
mabuse@physics.carleton.ca

NSERC USRA (Undergraduate Summer Research Award): NSERC is the Natural Sciences and Engineering Research Council, the primary Canadian research funding agency for people working in physics. The NSERC USRA is a Canada-wide, NSERC-sponsored student research program in which students are placed with a faculty supervisor for the summer. Students finishing their 2nd, 3rd, or 4th or later year of an honours physics program are eligible. You must be a Canadian citizen or permanent resident and have a cumulative average of at least a B+ with no failures. The position is normally for four months and provides a stipend of around $2500–$2700 per month. More information, including project descriptions and application instructions, is available at http://www.physics.carleton.ca/current-undergraduate-students/research-positions.

Available positions at Carleton will be advertised in the Physics Department starting in November for the following summer. Positions are also available at other Canadian universities. The application deadline is generally early to mid January. The USRA coordinator for Carleton Physics is Prof. Kevin Graham:

USRA Coordinator:
Prof. Kevin Graham
3322 HP
(613) 520-2600 ext. 4373
mabuse@physics.carleton.ca

Institute of Particle Physics CERN Summer Undergraduate Research Experience:
This program gives undergraduate students the opportunity to spend around nine weeks at the
CERN laboratory in Geneva, Switzerland, working with active research groups on particle physics, detector development, or accelerator physics. The program provides airfare to and from Geneva as well as a stipend to cover living expenses at CERN for five students each year. Applicants must be Canadian citizens or permanent residents. For more information, see [http://www.ipp.ca/programs/CERN_summer.shtml](http://www.ipp.ca/programs/CERN_summer.shtml).

**TRIUMF Summer Research Awards:** This highly competitive program allows five Canadian students each year to experience a summer of research at TRIUMF, Canada’s national laboratory for nuclear and particle physics, on the UBC campus in Vancouver. TRIUMF is home to a 500 MeV cyclotron and smaller isotope production cyclotrons which support a diverse program of world class research in particle physics, nuclear physics and chemistry (including nuclear astrophysics), condensed matter and materials research, and life sciences. In addition, TRIUMF acts as an infrastructure lab for international collaborations in subatomic physics at other laboratories around the world.

Last year the program paid a salary of $1900 to $2700 per month over the summer plus a $2000 scholarship and return airfare from the student’s home institution.

The application deadline is in January for the following summer. For more information, see [http://www.triumf.ca/studentaward](http://www.triumf.ca/studentaward).

**Co-op:** Co-op placements provide another opportunity for involvement in research, through local and province-wide businesses and industry. Co-op placements within Carleton University and Physics Department research labs are also sometimes available. For more details, see Sec. 12.

### 12 Co-op

The co-op program allows the student to mix academic study with work experience. Through a sequence of four and eight month work terms, students in the Co-operative Education Stream complement the theoretical knowledge acquired during the academic terms with practical work experience in their areas of career interest. This stream allows students to explore various career possibilities first hand and thereby gain a better understanding of the expectations and requirements of their chosen profession. Co-op education leads to personal and professional development for students and can assist in the financing of their education and selecting that important first job on graduation.

Qualified students typically apply for the co-operative stream during their second year in the program, with the first work term taking place after the completion of second year. Exceptional students may apply for co-op in their first year with the first work term taking place after completion of the first year. The normal work/study sequence requires a minimum of four 4-month work terms. The same number of academic courses (20 credits) is required as the usual Honours program so this program will normally take an extra year to complete.

In order to qualify for the co-op program you must:

- Be eligible to work in Canada
- Be registered as a full time student in one of the Physics Honours B.Sc. programs
- Have a minimum cumulative honours grade-point average of 8.0 (B) or better and an overall G.P.A. of 6.5 or better.
For more information on the co-op program, see http://www5.carleton.ca/cc/co-operative-education/
The co-op advisor for Physics is Prof. Sangeeta Murugkar:

Co-op Advisor:
Prof. Sangeeta Murugkar
2414 HP
(613) 520-2600 ext. 4016
coop@physics.carleton.ca

13 Departmental Awards

As a current undergraduate in the Physics Department, you will automatically be considered for the department’s annual awards. No individual application is required on your part, and awards are generally given to students in all years of our programs. The awards are based on academic excellence. The department’s awards provide recognition for our top students as well as a prize typically of several hundred dollars.

Awards are usually announced to the recipient during the summer, and announced to the department at the annual Undergrad Welcome Lunch near the middle of September. For a complete list of the departmental awards, see http://www.physics.carleton.ca/current-undergraduate-students/awards-and-scholarships.

An award, funded by NSERC, is also made annually for the best fourth-year project (PHYS 4907/4908/4909) oral presentation.

14 Applying to Grad School

After the completion of the Honours Physics programs, many students wish to continue their studies in physics or related fields through postgraduate studies. Applications to grad schools must be made as early as February 1 of your final year for grad schools in Canada, and even earlier for many schools abroad.

Grad scholarships: Applications for external graduate scholarships are typically due very early, in September or October of the final year of the Honours program. Major external graduate scholarships for M.Sc. programs include the Ontario Graduate Scholarship (OGS, $15,000 for one year) and the Natural Sciences and Engineering Research Council (NSERC, $17,500 for one year). Even if you are not yet sure whether you’ll be applying to grad school, you should still apply for these awards in the fall of your final year. The application process is rather involved and is worth starting early. Workshops are held on campus every September to guide you through the process. Applications for external scholarships also require letters of recommendation from two or three faculty members, which should be requested at least two or three weeks before the deadline.

The grad school application process: The most important factors for getting into grad school are your marks—especially within your major and especially for the most recent two years—and letters of recommendation from faculty members. Generally two or three recommendation letters are required for grad school applications. The most valuable letters come from professors or supervisors who know your work well and can say something about your abilities at research—someone who
has supervised you during a summer research project or fourth-year honours project is ideal! When requesting a letter of recommendation, it is always a good idea to ask early (at least two or three weeks before the deadline).

15 Careers in Physics

Physics graduates are highly sought-after employees. A physics education emphasizes problem solving and abstract thinking, and this training makes physics graduates very desirable employees in a wide variety of areas including education, finance, and journalism. These fundamental skills as well as training in practical subjects such as optics, lasers, computer interfacing, image processing and electronics also make them very desirable employees in high-tech companies.

The Canadian Association of Physicists maintains a fine resource on careers in physics at http://www.cap.ca/careers/careers.html, including interviews with physics graduates, employment statistics, and an extensive collection of links to job search resources and professional organizations. The American Institute of Physics also maintains a large collection of employment statistics and career information for physics graduates at http://www.aip.org/statistics/trends/career.html.

Professional Physicist certification: The CAP also offers the professional certification credential of Professional Physicist (P.Phys.) to designate a person with a high level of physics training and experience. It requires an Honours B.Sc. with a single or joint major in physics, at least three years of relevant experience, and the writing of the Professional Certification exam offered annually by the CAP in physics departments across the country. Details are at details at http://www.cap.ca/en/careers/pphys-certification.

Physics certification as a Professional Physicist can be an important addition to your personal credentials. Your university education demonstrates your knowledge as a scientist, but you need to show that you have sufficient communications proficiency and outside-the-lines thinking to distinguish you from other applicants looking for the first-rate job opportunities. Your designation as a Professional Physicist allows you to use the letters “P.Phys.” to show that you possess the qualities and experience required to make judgement calls with respect to scientific matters in your particular field. As a Professional Physicist, you understand and uphold the CAP’s Enhanced Code of Ethics and when solving problems, you do your best to consider all the different technical and societal matters that relate to your field of expertise.

The highly technical aspects of the day-to-day activities of a physicist often involve working together with other professionals, such as Professional Engineers, Chartered Accountants or even Members of the Royal Architects Institute of Canada. The CAP uses a title that is parallel in style to these other occupations. In so doing, the Association expects that professionals from outside the realm of the physical sciences will recognize the meaning of “Professional Physicist” as being a professional designation similar in nature to their own or similar to other designations with which they may already be familiar.