

The Leading Role of the Faculty of Sciences and Engineering of Laval University in the Development of Curricula in Optics/Photonics for Industry.

Roger A. Lessard, Eng.
Chairman

Department of Physics, Engineering Physics and Optics
Faculty of Sciences and Engineering

Laval University, Quebec City (Quebec) G1K 7P4, Canada

Tel: 418-656-2152; Fax: 418-656-2040; E-mail: ralessard@phy.ulaval.ca

ABSTRACT

Sometime ago, the Government of Quebec decided that a zone comprising Quebec City will become an Optics City. In Fact, this decision is based on long tradition of Optics that Laval University with the Defence Research Establishment of Valcartier (The Optics arm of the Canadian Defence Research Network) maintained for years despite the fact that Optics was not well seen as Research Domain.

The Optics City zone in which we can find the 'Groupe d'optique photonique Québec' (GOPQ- The Quebec City Optics Cluster) has decided that their first priority is to fulfill the needs of Optics/Photonics Specialists. As we know, this need is seen all over the world and every places where Optics/Photonics want to be done, wants to find or train this type of Specialists. The Faculty of Science and Engineering was appointed as the main player to organize such training in collaboration with a Network of College where Technicians are trained.

Keywords: Optics Program, Physics, Physics Engineering, Optics Engineering, Optics Education, Technicians.

HISTORICAL NOTES¹

Everyone who is interested by Optics knows the long way Researchers have done to bring this field where it is nowadays. This exclusion or non-inclusion of Optics has been seen all over the world. Some countries did understand faster that others.

In Canada, Optics was seen as somewhat ridiculous and no other universities than Laval pick up this field and supported it.

Laval University will be celebrating in 2002, its 150th anniversary under the English regime, will also be celebrating its 340th anniversary under the French Regime become French established it in 1663. Although Laval was established before most of the North American Universities, the development of Sciences started only in 1910. The Faculty of Sciences was founded in 1937 and the Department of Physics just after.

The Department and the Faculty were quite lucky that from the beginning, someone under the guidance of Prof. Franco Rasetti, founding Chairman of the Department of Physics, decided to develop Optics as a research domain. Prof. Albéric Boivin devoted his career to do research and training in Optics. He has been instrumental in the formation of the first research team (LOH) having Optics as a theme, he participated in the formation of LROL and was supervisor of many Master and Doctorate Thesis.

The Faculty of Sciences was named Faculty of Sciences and Engineering in 1985 to show the importance of having under a unified roof both pure and applied sciences. In 1989, Researchers grouped together researchers interested in Optical Sciences and Engineering to form the Center for Optics, Photonics and Lasers (COPL).

Recently, officially on 6th March 2001, the Department of Physics was renamed Department of Physics, Engineering Physics and Optics and took over not only the program of Physics but also the Program of Engineering Physics as well as the new program in Optics/Photonics.

IMPORTANCE OF RESEARCHERS IN OPTICS IN CANADA

As said before, Laval University through his Department of Physics was the only University where it was possible to study this field at undergraduate and graduate level. At about the time that was established the Department of Physics and the Faculty of Sciences, the Government of Canada decided to build its Arms Development Research Center in the vicinity of Quebec City. This research center was right at its beginning involved in vision research, tele-detection and all research related to light. National Research Council of Canada, located in Ottawa, was mainly looking at standards, spectroscopic tools.

Researchers of all those three labs were, to use a modern word, networking. At this time, most of the Canadian Specialist in Optics working in Governmental Labs, Universities and Companies have been trained in Laval University.

The disclosure of the TEA-CO₂ Laser around 1970 was an important milestone for Canada and for Quebec City. In effect, researchers of the DREV-Defence Research Establishment of Valcartier (City located in the Suburban of Quebec City) succeeded under the guidance of Dr. Jacques Beaulieu, to build this high power laser. In his team, there was researcher of Laval University.

The importance of this development in the laser area and the number of Researchers and Specialists in Optics trained at Laval University was so evident that the Government of Canada decided, in 1985, to establish an Institute of Optics (a branch of the National Research Council of Canada) in Quebec City. Politics changed the status of this decision and instead of that Institute, an Industrial Research Center granted by both Quebec and Canadian Governments was started. It was named National Optics Institute (Nowaday, it is know as INO for Institut national d'optique).

Gentec, Inc received the mandate from the DREV to develop and commercialize the CO₂-TEA Laser, Bomem (a start-up from DREV) begun, INO (National Optics Institute) was created, DREV continue his development, COPL was formed and a new company EXFO (created by two students of Laval University, one after a Master in Physics and the other after his B.Sc. in Electrical Engineering) was started. All that happens due to researchers working in Quebec City area.

A non-profit organisation was created in 1998 during an SPIE meeting. Presidents of Companies seated together and after a talk of the President of the Tucson Cluster in Optics, They decided to start the 'Groupe d'optique-Photonique Québec' translated in English as the Quebec Optics Photonics Cluster.

QUEBEC CITY IS AN OPTICS CITY

All the development cited in the previous section convinced the Government of Quebec to declare Quebec City, the Optics City linked with funds to help Research and Development and the Start-up of new High-Tech Industries.

Prior to that or in the same period, many Small and Medium Size Entreprises started. The synergy running between Research Laboratories, Governmental Laboratories which was helping the development of start-ups, the collaboration between companies and

funds becoming available thanks to Quebec Government Policy helps to create many new companies working in Optics or related to Optics.

As it was the case all over the world, Companies, Governmental Laboratories and Universities were looking to find candidates to be recruited as researchers, managers, scientists, technicians and for their department of sales and services. The situation was such that Companies were fighting to get the available candidates, they were even taking undergraduate students.

The Dean of the Faculty of Sciences and Engineering of Laval University worked out a project in collaboration with all Colleges who wanted to train technicians that permit to create an unique counter, supported by the organisation of the Optics City, where companies will be able to address their requests for training their own technicians, their own engineers that were not trained to work in the field of Optical Sciences and Engineering. This unique counter will also works programs that will fulfill the industrial needs.

ROLE OF THE FACULTY OF SCIENCES AND ENGINEERING

Consequently, the Dean of the Faculty of Sciences and Engineering, Pierre Moreau, the Vice-Dean for Education, Richard Poulin, the Director of the Center for Optics, Photonics and Lasers, Réal Vallée, the Chairmen of the Department of Physics, Engineering Physics and Optics, Roger A. Lessard, and of the Department of Electrical and Computer Engineering, Paul Fortier, the Président of the Optics City, Régis Labeaume, the President of the Cluster in Optics, Michel Bédard plus René Beaulieu, representing the CEGEP La Pocatière and some delegates from other institutions build up a very large program that will answer requests coming not only from Québec City but from all the Province of Québec and from the Canada.

A sub-committee made an extensive review of all available programs for training technicians, engineers and scientists who might be used to fulfill the needs. An other sub-committee from the Faculty of Sciences and Engineering did work on a short program that will help to reorient the career of Mechanical, Electronic, Electrical, Computer and Chemical Engineers and to give them some basic knowledge in Optics/Photonics. This program can also be used by Scientist as Chemists, Biochemists and Biologists.

TECHNICIANS

At CEGEP La Pocatière, students receive a practical and theoretical formation all along their 3 years of college.

Outside Math, Chemistry and Physics, someone who wants to become a Photonics Technician must take courses which are designated as mandatory for a Photonics Technician.

The 3 year course is made of 6 terms of 15 weeks during which the students are following 28 hours courses per week.

To be specialized in Optics/Photonics, the Photonics Technician has taken courses on Geometrical Optics, on Instrumental Optics, Optical Fibers, Lasers, Sources and Detectors, Application to infrared. The technician knows the Vacuum techniques and got basic knowledge of Photometry and Radiometry.

Although training in industry is not mandatory since they get many labs all along their formation, most of the students passing by CEGEP La Pocatière decided to do some months in Industry prior to graduate.

Program at CEGEP La Pocatière:

1st session:	Philosophy and rationality	(60 Hours)
	Writing and Literature	(60 Hours)
	Sports	(30 Hours)
	Mathematical Models 1	(75 Hours)
	What is a Technologist?	(45 Hours)
	Technology of Electricity	(105 Hours)
	Computer as a tool	(60 Hours)
2nd session:	Human Being	(45 Hours)
	Literature and Imagination	(60 Hours)
	English	(45 Hours)
	Mathematical Models 11	(75 Hours)
	Design and construction of A Control System	(105 Hours)
	Circuits	(105 Hours)

3rd session:	Quebec Literature	(60 Hours)
	English for Programming	(45 Hours)
	Technical Drawing	(60 Hours)
	Signal Processing	(75 Hours)
	Technics of Technical	
	Physics Technology	(75 Hours)
	Sports	(75 Hours)
4th session:	Public communication	(60 Hours)
	Administration	(75 Hours)
	Matter and Heat	(75 Hours)
	Optical Instruments	(60 Hours)
	Technics of Vacuum	(75 Hours)
5th session:	Philosophy	(45 Hours)
	Projects I	(90 Hours)
	Sensors	(75 Hours)
	Physical Optics	(60 Hours)
	Materials and	
	Photonics Devices	(60 Hours)
6th session:	Waves and Acoustics	(60 Hours)
	Data Processing	(75 Hours)
	Projects II	(90 Hours)
	Automatisation	(75 Hours)
	Physical Optics	(60 Hours)
	Optical Fibers	(60 Hours)
Lasers	(45 Hours)	

There is also a re-orientation program form Technician who were not in this Optics-Photonics branch. This program was designed to be given in parallel with the previous one in 1500 Hours; 67 weeks @ 25 Hours per week.

CEGEP Limoilou and François-Xavier Garneau which were not having a specific program in that field, decided to designed courses that will be taken in industry. They, in collaboration with CEGEP La Pocatière, develop complementary courses that can be thought during the working hours on the working sites.

SCIENTIFIC DEGREE IN OPTICS AND PHOTONICS

1-Sciences Degree in Physics (Optics specialization)

In the Province of Québec, the first year that we can find in most of the country, has been transferred to CEGEP. So, to compare with others, one must see our three years of training as being made of one or two courses of the 2nd year and the courses of the 3rd and 4th year.

Bachelor degree in Sciences (B.Sc. (Physics) with Specialization in Optics)

Length: 6 terms (90 credits)

Mandatory courses²: 75 credits

PHY-10484	Introduction to Astrophysics
PHY-10485	Mathematical Physics I
PHY-10486	Mathematical Physics II
PHY-10489	Classical Mechanics I
GML-21452	Material Sciences
PHY-10487	Mathematical Physics III
PHY-10493	Quantum Physics
PHY-18757	Electromagnetism
PHY-10491	Waves and Linear Systems
PHY-20921	Experimental Physics I
PHY-10492	Classical Mechanics II
PHY-10501	Electromagnetic Waves
GEL-19962	Signals Analysis
PHY-20922	Experimental Physics II
IFT-17582	Algorithm and programming
PHY-10502	Optics
CHM-10099	Physical Chemistry I (Thermodynamics)
PHY-17322	Quantum Mechanics I
PHY-20923	Experimental Physics III
PHY-20924	Experimental Physics
PHY-10508	Statistics Physics
PHY-18760	Quantum Mechanics II
PHY-17323	Solid State Physics
MAT-18996	Numerical Analysis
PHY-20925	Experimental Physics V

Optional courses: 15 credits

PHY-20912	Photonics and Lasers
GPH-21587	Introduction to Optical Design
GPH-21029	Lasers and Applications
GPH-21335	Optical Waveguides
GPH-14306	Instrumental Optics
GEL-17982	Optical Communications
PHY-10527	Project I
PHY-21465	Practicing in Physics

2- Engineering Degree in Physics

Physics engineering was completely remodeled and it was made up of a compulsory core plus optional specialization. Of course, one of those specializations was Optics and it contained a mandatory course for Physics Engineers, Instrumental Optics and courses like Guided Optics, Optics for Communications, Physical Optics, Advanced Optics.

Bachelor Degree in Applied Sciences or Engineering (B.Eng(Physics) Specialization in Photonics and Telecommunication); Length 8 terms (120 credits)

Mandatory courses: 105 credits

GLG-17523	Earth Geophysics
PHY-17033	Physics Engineering Practice
PHY-10485	Mathematical Physics I
PHY-10486	Mathematical Physics II
GMC-10284	Technical thermodynamics
IFT-20545	Computing for Engineer
PHY-10487	Mathematical Physics III
PHY-10491	Waves and Linear systems
PHY-18757	Electromagnetism
MAT-18996	Numerical Analysis for Engineer
COM-21573	Engineering Design and Communication
GMC-10302	Techniques of Mechanics II
GIF-10279	Logic Circuits
GMC-10292	Mechanics of fluids I
GML-10463	Materials for Engineer
PHY-10501	Electromagnetic Waves
PHY-10493	Quantum Physics
GPH-14306	Instrumental Optics

GEL-16132	Circuits
GMN-16209	Health and Security for Engineer
One language course	
STT-20694	Probability for Engineers
GMC-20708	Thermal transfer
GMC-10301	Material Resistance I
GPH-14308	Atomic and Nuclear Physics
GPH-16103	Laboratory of instrumentation
PHY-17323	Solid state Physics
GMC-17694	Modeling and analysis in CAO
GPH-18756	Advanced Laboratories
GPH-17443	Project I
GPH-17444	Project II
ECN-15452	Economic Analysis and Engineering
SOC-17707	Sociology of technological innovation
GMC-10282	Drawing for Engineer or GPH-20391 Stage Physics Engineering

Specialization courses for Photonics and Telecommunications: 15 credits

Take one of the following courses: 3 credits

GEL-19962	Signal analysis
GPH-21334	Element of photonics

Take other credits among the following courses¹:

GEL-10280	Digital Communications
GEL-16120	Communication Systems
GEL-17982	Optical Communications
GPH-21029	Lasers et applications
GPH-21335	Optical Waveguides
GPH-21587	Introduction to Optical Design

3- Engineering Degree in Electrical Engineering

In recent years and mainly due to the fact that 5 faculty members of the Department of Electrical and Computer Engineering joined the 12 faculty members of the Department of Physics to form the Center for Optics, Photonics and Lasers, Electrical Engineering did add some courses related to Optics like one on Optics Materials, Diode lasers and applications.

4- Optics Flavor to the other Engineering Programs

Laval University, after the survey mentioned at the beginning of this section decided to create a Certificate that will permit to Mechanical Engineers, Electrical Engineers, Computer Engineers, Chemical Engineers, Chemists, Biochemists and Biologists to take two full intensive sessions on Optics. This will permit to the Scientists and Engineers employed in the Optics related industries to communicate more easily with Physicists and Physics Engineers.

Certificate in Optics/Photonics (30 credits)

Basic and common courses (15 credits)

GEL-22009	Electromagnetism	PHY-22010	Fiber Optics
PHY-22011	Lasers	PHY-22012	Wave Optics
PHY-22013	Classical Optics		

Specialization in Optics (15 credits)

GEL-22014	Optoelectronics	PHY-22015	Diffraction and Fourier Optics
PHY-22016	Optical Design	PHY-22017	Opto-Mechanics
PHY-22021	Instrumental Optics		

Or

Specialization Optical Communications (15 credits)

GEL-22014	Optoelectronics
GEL-22018	Optical Communications Systems
GEL-22019	Optical Communications Networks
GEL-22020	Industry of Telecommunications
GEL-xxxx	Optional Course to be defined

REVIEW OF THE ROLE OF THE FACULTY OF SCIENCES AND ENGINEERING

As we have seen in this paper the role of the Faculty of Sciences and Engineering of Laval University was of primary importance in the development of Optics in Québec and in Canada starting from its establishment in 1937.

Laval University has granted a large number of Bachelor degrees in Physics and Engineering Physics and we must admit that an important part of those Physicists and Physical Engineers play a role in the development of Optics in Quebec as well as in Canada.

From the 1st Professor in Optics in 1944 to the 17 Professors doing presently research in the Center for Optics, Photonics and Lasers and lecturing in the Department of Physics, Engineering Physics and Optics and the Department of Electrical and Computer Engineering, University Laval has delivered more than 250 M.Sc. and 150 D.Sc. or Ph.D.

Laval University had trained most of the scientific working in Optics in Canada until 1990. Some of those 500 graduates who received diploma from Laval University can be found in Canada, France, Belgium, Brazil, China, Columbia, Japan, Mexico, Morocco, United States of America, Iran, Iraq, some African Countries, etc.

At the undergraduate level, the Creation of the Optics City by the Government of Quebec and the conferences made by the members of the recruiting committee of the Faculty of Sciences and Engineering permitted the inscription of 100 new students in the program of Engineering Physics and 50 new students in the program of Honours in Physics. Being limited due to the number of Professors in the Departments of Physics, Engineering Physics and Optics and of Electrical and Computer Engineering, we had to restrict ourselves to 90 graduates students at Master and Ph.D. levels.

Reference:

1. Roger A. Lessard (Invited), "Fifty-five years of Optics as a teaching and research domain at Laval University", Sixth Conference on Education and Training in Optics and Photonics (ETOP'99), Cancún, México, 26-30 July (1999). Proc SPIE 3831, 36-46 (1999).
2. Definition of a credit at Laval University:
1 credit = 1 hour of lecture during 15 weeks plus 2 hours of personal work.