

A New Venture in Graduate Education:

CO-OP PH.D. PROGRAMME IN CHEMICAL ENGINEERING

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SINCE WE INTRODUCED ourselves to *CEE* readers some years ago [1], our cooperative system has continued to enjoy unperturbed growth. While ten years ago several hundred industrial and governmental employers participated in the co-op scheme of undergraduate education, this year their total number is about 5,000, and about 1,800 are employers of engineering students. With roughly one-half of our student population (6,600) in the co-op programme, Waterloo is now the second largest fully cooperative engineering school in North America and the largest in Canada, where Sherbrooke, Memorial, Regina and Victoria also have cooperative arrangements.

Much of this success is due to the efforts of our Co-ordination Department which is engaged full-time in arranging recruiting interviews and in looking after students on their work terms; there are twelve full-time engineering coordinators (all graduate engineers) devoted entirely to the engineering contingent of the programme. They are very busy.

The graduate arm of engineering education at Waterloo has grown essentially in a classical pattern and the "full-time-research-on-campus" scheme has been predominant especially in the Ph.D. programme, whose normal maximum duration past the M.A.Sc. degree is four years. While special arrangements may be made for part-time and off-campus Ph.D. studies, the advantages of the cooperative scheme, amply documented on the undergraduate level, have not yet been explored sufficiently in our post-graduate education. The co-op Ph.D. programme is, in our opinion, the first significant step in this direction with two major goals in mind:

- To enable participating students to attain important practical experience, discipline and organizational ability in an industrial environment during the external period and to prepare for a comprehensive effort on their chosen research topic.
- To provide participating employers (industrial and governmental) with an enhanced opportunity to be-



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come acquainted with the qualifications and the scholarship of Ph.D. candidates.

The structure of the Co-op Ph.D. programme is shown in Table 1. Canadian citizens and landed immigrants who possess a Bachelor's degree in Chemical Engineering from a recognized university and have a minimum average final grade of 78% are admissible; the grade minimum is five per cent higher than the minimum requirement for the standard Ph.D. programme and the citizenship/immigration status is required by current government regulations of financial support and employment conditions. Each application is individually evaluated by the Associate Chairman of Graduate Studies and the departmental Graduate Review Committee before recommendation is formally made to the Associate Dean of Graduate Studies of the engineering faculty. The minimum average grade obtained in graduate courses taken in the programme must

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TABLE 1
Structural Characteristics of the Co-op Ph.D. Scheme

PHASE AND DURATION	FUNCTION	FINANCIAL ASPECTS	REMARKS
1. Preparatory; two consecutive terms	Six graduate courses. Teaching Assistantship duties. Interviews with prospective employers for employment in the second phase.	Teaching assistantships, departmental bursaries and external scholarships	Entry in any of the Winter, Spring and Fall terms. Strict admission requirements. High minimum course average to be maintained.
2. Industrial; three consecutive terms	Practical (research) experience in a nonacademic environment. Preparation of a comprehensive work report describing the off-campus professional activities.	Market-level salaries.	Employment obtained via services of the Co-ordination Department.
3. Research; minimum two years	Two graduate courses. On-campus research project. Comprehensive oral examination. Submission of Ph.D. thesis and oral defence.	As in phase 1.	High minimum course average and high quality of research performance to be maintained.

be 75% at any given time (also five per cent higher than the minimum requirement in the standard Ph.D. programme); this is a prime condition for maintaining a candidate's satisfactory status, apart from specific conditions pertaining to each of the three phases.

The work period and the work report form a crucial component of the programme. In the industrial phase candidates acquire not only material and disciplinary experience in industry but they are also expected to derive special skills and motivation which will enable them to carry out original and high-quality research in the third phase. The work report should demonstrate to the employer a candidate's ability to do lucid and concise technical writing, and it should also serve as a "mini-rehearsal" for the research thesis. Higher than normal intramural earnings in the work period constitute the pecuniary benefits of the second phase.

The research phase resembles to a large extent its counterpart of the standard Ph.D. programme. The thesis topic is chosen via consulting with an officially appointed faculty supervisor who will advise and direct the candidate throughout the research project. The comprehensive oral examination of the proposal by a faculty-appointed committee is to be passed not later than six months after return to campus and the oral thesis defence

is to be passed upon submission of the doctoral thesis.

There is no Master's degree in this scheme; it leads directly to the Doctor's degree. We feel that this feature is attractive to those who are determined to seek the highest degree of formal education while defying the risks of a shorter unconventional path.

We at Waterloo believe that this scheme is a rewarding challenge to highly mature and self-disciplined students by offering, apart from the technical knowledge and aptitudes accumulated in both academic and off-campus periods, a wider perspective of the chemical engineering profession and of personal career development. One additional benefit that may accrue from the enhanced mutual awareness and cooperation between the University and employers of chemical engineers, which this effort necessitates, is the emergence of Ph.D. thesis topics with an academically respectable and yet industrially practicable substance.

A flyer and further details of the programme are available from the Department of Chemical Engineering, University of Waterloo.

REFERENCES

1. M. Moo-Young, "Ch.E. Department: Waterloo", Chem. Engrg. Educ. IX (5), 4 (1975).