DOCUMENT RESUME

ED 068 072 HE 003 525

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TITLE	Undergraduate Engineering Enrollment Projections for Ontario, 1970-80.
INSTITUTION	Committee of Presidents of Universities of Ontario, Toronto.
REPORT NO	CPUO-R-70-1
PUB DATE	Oct 70
NOTE	77p.
AVAILABLE FROM	Secretariat of the Committee of Presidents, 230 Bloor Street West, Toronto, Ontario, Canada
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Educational Demand; Engineering; *Engineering Education; *Enrollment Projections; *Higher Education; International Education
IDENTIFIERS	*Canada

ABSTRACT

Enrollment projections are vital to the planning of any educational system where capacity and growth are important elements. As a portion of a study of engineering education in Ontario, this document presents enrollment projections up to academic year 1980-81, that size and number of engineering schools to be needed might be established. Tables are presented giving data on: (1) full-time undergraduate engineering enrollments in Ontario universities from 1941-1969; (2) Ontario undergraduate enrollment growth from 1961-69; (3) an analysis of firsts and seconds in physics and chemistry; (4) students qualified for engineering; (5) age distribution of Ontario engineering undergraduates in 1968-69; (6) grade 13 students qualified to enter engineering; (7) total full-time undergraduate engineering enrollment projections at provincially assisted Ontario universities to 1980-81; and (8) projected engineering bachelor's degree output at provincially assisted universities in Ontario from 1968-81. (HS)

Committee of Presidents of Universities of Ontario
Comité des Présidents d'Université de l'Ontario

Undergraduate Engineering Enrolment Projections for Ontario, 1970-80

by
Philip A. Lapp

CPUO Report No. 70-1
October 1970

UNDERGRADUATE ENGINEERING ENROLMENT PROJECTIONS FOR ONTARIO, 1970-1980

By
Philip A. Lapp

A REPORT SUBMITTED TO
THE COMMITTEE OF PRESIDENTS OF UNIVERSITIES OF ONTARIO
FOR THE STUDY OF ENGINEERING EDUCATION IN ONTARIO

October 1970

PUBLISHED RESEARCH STUDIES BY THE COMMITTEE OF PRESIDENTS OF UNIVERSITIES OF ONTARIO RELATED TO THE STUDY OF ENGINEERING EDUCATION IN ONTARIO

(Available from the Secretariat of the Committee of Presidents, 230 Bloor Street West, Toronto 181)

CPUO Report No. 70-1	"Undergraduate Engineering Enrolment Projections for Ontario, 1970-1980," Philip A. Lapp. October, 1970.
CPUO Report No. 70-2	"An Analysis of Projections of the Demand for Engineers in Canada and Ontario and An Inquiry into Substitution Between Engineers and Technologists," M. L. Skolnik and W. F. McMullen. November, 1970.
CPUO Report No. 70-3	"A Method for Developing Unit Costs in Educational Programs," Ivor Wm. Thompson and Philip A. Lapp. December, 1970.

This is a report of a background study to _Ring of Iron: A Study of Engineering Education in Ontario_ (Toronto: Committee of Presidents of Universities of Ontario, 1970). The views expressed herein are those of the author and do not necessarily represent those of the Committee of Presidents of Universities of Ontario.

UNDERGRADUATE ENGINEERING ENROLMENT PROJECTIONS
FOR ONTARIO, 1970-1980

PREFACE

This report is intended to be a source document in support of the CPUO Study of Engineering Education in Ontario for the decade 1970-1980. The main report was published by CPUO under the title Ring of Iron in December 1970. Enrolment projections are vital to the planning of any educational system where capacity and growth are important elements. For the Engineering Study, they form the basis for establishing the size and number of schools in the system, and thus are fundamental to many of the recommendations. For this reason, enrolments warranted special attention.

An objective of the post-secondary educational system in Ontario is to meet the demand for student places by graduating high school students within the Province. Future enrolments in engineering will be established by the social demand for places, within the physical ability of the universities to provide such places, and by no other factor. The requirements for engineers in Ontario, or in Canada, are not covered in this report in any detail.

Enrolment data were provided by the universities in submissions made in response to a questionnaire related to the main Study. This information was used extensively for developing the projections.

The author is indebted to the other members of the study group for the main Study: Dr. C. B. Mackay, for his initial editing, and Dr. J. W. Hodgins, for his suggestions and constructive criticisms. Illustrations were prepared by Miss Valda Steet, and final editing was carried out by Mrs. Barbara Brougham, each of whose efforts are recognized and appreciated. Finally, the author is grateful to the CPUO staff who contributed ideas: Mr. Ivor Wm. Thompson, in research; Miss Susan Cale and the secretariat staff, in the preparation.

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> All we can ever predict is continuity that extends yesterday's trends into tomorrow. What has already happened is the only thing we can project and the only thing that can be quantified. But these continuing trends, however important, are only one dimension of the future, only one aspect of reality.
>
> The most accurate quantitative projection never predicts the truly important: the meaning of the facts and figures in the context of a different tomorrow.
>
> Peter F. Drucker,
> The Age of Discontinuity
> (New York: Harper and Row, 1968).

At this particular time, perhaps more than at any other, the projection of enrolments is a hazardous undertaking. As the accompanying data demonstrate, we are in a period of rapid change - in the high schools and in the universities, in the number of people reaching university age and, of first importance, in the attitudes and inclinations of our young people. For these reasons, we have collected and analyzed an unusually large number of data; and with the use of a regression model, we have undertaken to develop several separate methods for arriving at projected engineering enrolments spanning the present decade. For purposes of planning, we have chosen the projection in Figure 17, giving total undergraduate engineering enrolment of 13,000 in Ontario provincially-assisted universities in the academic year 1980-81.

Figures 1a and 2 give the full-time undergraduate engineering enrolments from 1941-42 to 1969-70. Data for these curves are given in Table 1. The purpose of this report is to project both of these curves to the academic year 1980-81.

The Population Wave

Approximately 85% of undergraduate students in Ontario are from that province,[1] and so it appears reasonable to utilize Ontario statistics and high school data. Figure 1b shows the spectacular rise in the number of young people in the university enrolment age range (taken as the 18-21 age group) over the past twenty years and projected to 1980.[2] The slow climb of the 1950s became more rapid in the early 1960s and will continue, though slowing somewhat, throughout the 1970s.

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1 Z. E. Zsigmond and C. J. Wenaas, Enrolment in Educational Institutions by Province, 1951-52 to 1980-81, Staff Study No.25, Economic Council of Canada, January 1970, p.219.

2 Cicely Watson and Saeed Quazi, Ontario University and College Enrolment Projections to 1981-82, OISE Enrolment Projections No.4, 1968, pp. 12 and 14.

TABLE 1

FULL-TIME UNDERGRADUATE ENGINEERING ENROLMENTS 1941-69

ONTARIO UNIVERSITIES

Academic Year	First-Year Engineering Enrolment	Total Engineering Enrolment	
1941-42	670	1,719	Sources: Data from 1941 to 1959, from Engineering Institute of Canada, *Engineering Journal*, generally reflect early Fall registrations.
1942-43	818	2,008	
1943-44	563	1,739	
1944-45	596	1,711	
1945-46	742	2,435	
1946-47	2,367	5,642	
1947-48	1,477	5,610	
1948-49	836	5,110	
1949-50	679	3,908	
1950-51	664	2,917	
1951-52	723	2,346	
1952-53	923	2,410	
1953-54	894	2,591	
1954-55	1,058	2,938	
1955-56	1,046	3,132	
1956-57	1,187	3,416	
1957-58	1,431	3,860	
1958-59	1,372	4,123	
1959-60	1,247	4,220	
1960-61	1,213	3,791	Data from 1960 to 1969, from submissions received from Ontario Universities, reflect engineering enrolments as of December 1 each year.
1961-62	1,284	3,823	
1962-63	1,470	3,922	
1963-64	1,706	4,401	
1964-65	1,870	4,894	
1965-66	2,233	5,685	
1966-67	2,581	6,415	
1967-68	2,735	7,218	
1968-69	2,789	8,002	
1969-70	2,676	8,502	

Table 2 illustrates the increasing participation rate of young people of university age. Over the past decade, there has been an increase of nearly 10 percentage points in the proportion of those in the 18-21 age group attending university as undergraduates.

TABLE 2

ONTARIO UNDERGRADUATE ENROLMENT GROWTH 1951-1969

Year	Percentage of 18-21 Age Group who are Undergraduate Students	Total University Undergraduate Enrolment[a]
1951-52	8.0	21,123
1956-57	9.1	25,637
1957-58	9.5	27,452
1958-59	10.3	30,456
1959-60	10.9	33,145
1960-61	11.7	36,231
1961-62	12.3	39,026
1962-63	12.3	41,455
1963-64	12.8	46,400
1964-65	13.5	51,831
1965-66	14.3	58,037
1966-67	15.2	67,396
1967-68	16.2	76,160
1968-69	18.7	90,370
1969-70	20.8	100,500

a Z. E. Zsigmond and C. K. Wenaas, Enrolment in Educational Institutions, Tables A-43 and A-42 - Full-time undergraduate enrolment (including Teachers' Colleges).

This "population wave" in the universities has been accommodated by an unprecedented expansion of facilities, made possible by an accelerating increase in the flow of both operating and capital grants from the Provincial Treasury.

High School Enrolments

In Ontario, most engineering students enter university immediately after grade 13.[3] Therefore, it is important to analyze the enrolment dynamics in the high schools since, as will be shown, these have a profound effect on engineering enrolments. Parts a and b of Figure 3 present the actual enrolment growth for grades 12 and 13, projected by the Ontario Institute for Studies in Education (OISE) up to 1980-81.[4]

In 1966-67 there was a sharp decline in numbers in grade 13, undoubtedly caused by the reorganization of the secondary schools (usually referred to as the Robarts Plan) introduced in 1962. It diversified the secondary schools by creating a number of branches (arts and science; business and commerce; and science, technology and trades) and programs of varying length (two, four and five years). With a wide variety of optional subject arrangements, the two-year and four-year programs were designed to be complete in themselves, and not parts of longer courses of study. They were expected to lead either to direct employment, or to further study in the colleges of applied arts and technology. The five-year programs were to prepare students for university.

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3 In contrast to most other undergraduate faculties, engineering also draws from a pool of "adult" students - those who have worked for one or more years after grade 13; and advanced admissions occasionally are granted to students who did not complete grade 13, but who have had several years of relevant experience. The size of this pool is not known.

4 Cicely Watson, Saeed Quazi and Aubert Kleist, Ontario Secondary School Enrolment Projections to 1981-82, OISE Enrolment Projections No. 5, 1969.

Implementation of this plan has changed the distribution of enrolment within the secondary school. The arts and science branch (corresponding to the old general course) has declined in its percentage share in all grades with the exception of grade 13. Progressively greater numbers of students chose the four-year program rather than the five-year program terminating in grade 13.

The first effects were felt in grades 9 and 10 in 1962. The impact on grade 11 was seen in 1965 and on grade 12 in 1966. The growth in enrolment in four-year programs caused the decline in the grade 13 enrolments in 1966-67. The figures for 1968 indicate a levelling off.

In Figure 3c, the grade 12 enrolments in the five-year program are plotted, and these have been projected by OISE to 1980. It can be seen that the grade 13 survival rate from the grade 12 five-year program has remained approximately constant, while the survival rate from the total grade 12 population has been declining steadily.

Prior to the Robarts Plan, many students entered grade 13 even though they did not intend to proceed to university. Employers valued this advanced training and, in addition, many non-university post-secondary institutions required their candidates to take some grade 13 examinations. Thus, numbers in grade 13 were inflated by students for whom these courses were not designed. After 1966, however, a greater proportion of grade 13 students planned to enter university.

Influence of the CAATs

In 1965, legislation was passed creating the Colleges of Applied Arts and Technology (CAATs). Twenty such "Community Colleges" have been established, and the existing seven institutes of technology, with the exception of Ryerson Polytechnical Institute, were absorbed into the CAATs. Almost all of their students are from grade 12, in one, two and three-year programs. In general, applicants for admission to the three-year program must have a minimum standing of grade 12 from the five-year secondary school program; applicants to most of the other programs are admitted with any grade 12 diploma.

Although enrolments at the institutes of technology increased steadily from a total of 148 in 1945 to 7,884 in 1966,[5] first-year CAAT enrolments from grade 12 have accelerated at a much more rapid pace. In Figure 3d, first-year CAAT enrolments are shown subtracted from total grade 12 enrolments. The projections were made by OISE, and show the anticipated build-up of student flows into the CAATs from grade 12 over the present decade.

It is far too early to predict the impact of the CAATs on either the grade 12 five-year program or grade 13. It has been argued that the CAAT student is different from the university student, and that such a difference is discernible in high school. In general, the potential CAAT student is less academically oriented, has determined his career goals earlier, and perhaps is more practical. Students drawn from the grade 12 five-year program are likely to be from

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5 Department of Education, Technological and Trades Training Branch, October 1, 1966.

the lower end of the academic spectrum. We have concluded that the CAATs will have little influence on university enrolments. For the purposes of current planning, we have used the future enrolment estimates for grades 12 and 13 produced by OISE in 1969. These are presented in Figure 3, a and b.

Grade 13 Subject Performance

An analysis of the entrance requirements for the Ontario Engineering Schools reveals that, in 1969-70, grade 13 students must have successfully completed mathematics A, mathematics B, physics and chemistry. Other necessary subjects vary somewhat. A minimum standing (usually 60%) may be required in some or all of such subjects, together with a minimum over-all standing in grade 13.

Therefore, it was concluded that an analysis of these grade 13 subjects would be a useful exercise, for it should provide some insight into the academic preferences of young people preparing for university. Furthermore, any trends in the number of high school students taking these subjects would permit us to speculate on future prospects for enrolment, and perhaps indicate where efforts should be concentrated in high school guidance.

For the years before 1960, it was possible to obtain only the number of students who successfully completed the departmental examinations each year (50% standing or better). From 1960 on, these figures could be broken down into firsts, seconds, thirds, credits and failures. For consistency, Figure 4 shows the number of students achieving pass or better for the sciences - physics, chemistry, botany, zoology and biology - from 1930 to 1969. These curves follow grade 13 enrolments in a general way and show the dip that occurred in 1966-67 when the Robarts Plan hit grade 13. The smaller fluctuations may be accounted for by year-to-year variations in the relative difficulty of examinations or general student preferences, but even so, they are not significant.

Of greater interest is the percentage of passes in each grade 13 subject over the years. These are shown in Figures 5, 6 and 7. Figure 5 illustrates the percentage of grade 13 students passing in mathematics. Up to 1965-66, mathematics consisted of algebra, geometry and trigonometry, but in 1966 these subjects were replaced by mathematics A (introduction to analysis) and mathematics B (algebra). Figure 5 reveals a remarkably uniform consistency over the past forty years, with algebra the least popular subject, and all subjects falling within a 45-65% band (data points were taken only every five years between 1929-30 and 1944-45, and therefore any anomalies that may have occurred during the war do not show). Only four data points were available for mathematics A and mathematics B, but the split is interesting. Mathematics A continues in the same percentage band at the high end (60-65%), whereas mathematics B dropped to about 26%.

Mathematics A provides the student with two credits and is required by most faculties of science as well as engineering. Mathematics B is required for engineering, mathematics and some, but not all, faculties of science. This partitioning would appear to segregate grade 13 students with a real flair for mathematics.

Figure 6 shows the percentage of grade 13 students who passed in physics and chemistry. Both have been required by engineering and most science faculties. These curves reveal a very significant trend. Since 1955, there has been a declining interest in both of these subjects. From a high of 57% for chemistry and 46% for physics in 1955-56, the passes in these subjects have dropped to 41% and 28% respectively in 1969-70. Since both engineering and science faculties draw from this pool, such data will be used to undertake a projection.

Whereas Figure 6 shows only the percentage of students who passed, Figure 7 shows the performance of all students who took physics in grade 13. The total number of students taking physics has decreased even more rapidly because of declining failure rates. Also, it is interesting to note the relatively high consistency of those who achieve a mark of 60% or better (firsts, seconds and thirds). In recent years students who take physics appear to be better motivated and so have achieved improved standings, although other factors could account for the very recent higher mark distribution. Since the achievement of a pass in physics (credit or better), together with minimum over-all averages, is adequate to enter engineering, the pass curves of Figure 6 are used for projection purposes.

Because of consistently downward trend of the curves in Figure 6, comparable information was sought from other parts of the world. It was possible to locate some data for the United Kingdom in the Dainton Report[6], a study of science and technology student flows into higher education. It is assumed that second year "A" level in the United Kingdom is similar to Ontario grade 13, and G.C.E. "A" level examinations are comparable to Ontario departmental examinations. The results are shown in Figure 8. Data were available only for the years 1961-62 to 1965-66.

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6 Enquiry into the Flow of Candidates in Science and Technology into Higher Education, the Dainton Report, Cmnd. 3541 (London: H.M.S.O., 1968).

Mathematics has shown a steady decline over the period in the United Kingdom, while in Ontario it has remained relatively steady. This may be because "A" level specialization has existed for some time, and because science has been a branch separate from the others. The science branch has been declining, and this branch would include most students studying mathematics, as well as physics and chemistry. In Ontario, the introduction of the Robarts Plan, affecting grade 13 in 1966, would not show up here, but the sudden drop in mathematics B (algebra) in 1967 (shown in Figure 5) could be an indication of a similar trend in mathematics - at least for those destined for engineering or science.

There is a striking similarity in the two curves for physics. The drop in interest in physics appears not to be restricted to Ontario. The similar decline in chemistry in the United Kingdom cannot be easily compared to Ontario, which remained relatively steady during that period (see Figure 6, Ontario chemistry was not shown in Figure 8 because it overlapped with mathematics). It is interesting to note that the percentages in United Kingdom chemistry (24-30%) are much lower than Ontario (51%); there seems to be no reasonable explanation for this difference.

The third major science is biology, and Figure 9 is a plot of the percentage of grade 13 students who passed in this subject. Botany and zoology were separate subjects until 1965, when they were combined into the single subject of biology. Here, the trend is definitely upwards, which is perhaps explained by the growing concern of young people over our ecology and environmental pollution. There is every reason to believe that such a trend will continue for some time.

First-Year Engineering from Grade 13
Performance in Physics and Chemistry

Figure 6 can be used for enrolment projections, because there is reasonable consistency between the number of students who enter engineering and those who pass physics and chemistry. This is shown in Figure 10, a and b, where first-year engineering enrolments are plotted as a percentage of successful passes in grade 13 physics and chemistry the previous June. Although these quantities vary over ranges of several percent, they both show stable averages over the past twenty years. If this stability extends for the next ten, then it is possible to undertake a meaningful projection.

Both physics and chemistry curves in Figure 6 were smoothed and extended to 1980, on the assumption that the trend that has existed since the early 1950s will not reverse itself before 1980. (These extensions are shown as the smooth curves in Figure 6). Next, the freshman engineering percentages of passes in physics and chemistry data (Figure 10, a and b) were averaged over the past twenty years. Then a first-year projection can be undertaken using the OISE grade 13 predictions shown in Figure 3b, by multiplying the smoothed curves of Figure 6 by the corresponding averages and grade 13 enrolments. This yields a first-year engineering enrolment for 1980-81 of 2,460 using physics data, and 2,570 using chemistry data. The lower (physics) projection has been calculated for the intervening years and plotted in Figure 17 as the lower extension.

This prediction is based on the assumption that the declining interest in physics and chemistry will not reverse itself over the next ten years. Even if there are renewed efforts to revitalize interest in these subjects, it is doubtful whether any major change can be achieved rapidly enough to invalidate this assumption. As more of grade 13 is made up of university-bound students, in all likelihood the percentage of passes in physics and chemistry entering engineering will increase slightly, so this prediction will be somewhat pessimistic.

A major policy change that could alter this projection would be the dropping of grade 13 physics and/or chemistry as an entrance requirement for engineering. This would unlock engineering enrolments from the bounds clearly evident in Figure 6, and either or both of these subjects could be made up during the first year.

Flow into Engineering from Grade 13 Stocks

First-year engineering enrolments as a percentage of grade 13 enrolments in the previous academic year are plotted from 1945-46 to 1969-70 in Figure 11a. Following the hump caused by the veteran students, there was a rise for the next seven years which reached a peak in 1957-58 and then fell steadily until the early 1960s when it was reasonably stable, until another jump occurred in 1967-68.

Earlier it was suggested that after the 1967-68 academic year, grade 13 consisted of a greater proportion of university entrants. However, this could have been created by another phenomenon Grade 13 departmental examinations were given for the last time in June 1967, and since then, grade 13 marks have been established by each individual high school. When teachers mark their own students, there may be an upward bias in mark distribution. Both of these phenomena are revealed in Table 3.

Therefore, in any smoothing process, heavier weight should be placed on the last three years. The fall-off since 1957 is probably caused by the declining interest in physics and a swing toward pure science in the universities. This will be discussed in some detail later.

Finally, it was possible to obtain computer tapes of the results of every student in grade 13 for the past three years; earlier years were not available. An analysis of each year was conducted with these tapes to establish the number of students who actually qualified for engineering. For this purpose, "qualification" meant seven credits including mathematics A, mathematics B, physics and chemistry with a 60% weighted average. (This is an average qualification: many schools are higher, some are lower). Table 4 is the result of this analysis.

TABLE 3

ANALYSIS OF FIRSTS AND SECONDS IN PHYSICS AND CHEMISTRY

Year	Firsts and Seconds % of total papers written		Failures % of total papers written		% Graduated
	Physics	Chemistry	Physics	Chemistry	
1960	36.2	22.9	29.2	26.5	
1961	Not available		Not available		58.0
1962	31.5	32.3	17.6	19.4	54.1
1963	33.0	39.4	19.6	16.4	55.9
1964	34.7	36.8	17.9	18.3	56.5
1965*	34.2	30.0	17.6	19.0	58.7
1966	35.9	32.6	14.2	17.4	68.0
1967	47.1	37.2	9.0	14.6	68.0
1968+	45.0	47.0	10.0	10.0	79.2
1969	45.9	48.1	9.4	7.9	

* Robarts Plan hits grade 13.

\+ Departmental examinations cease.

TABLE 4

STUDENTS "QUALIFIED" FOR ENGINEERING

Year	No. Grade 13 Students Qualified in June	No. First-Year Engineering Students December 1	Percentage Those Qualified Who Enter First-Year Engineering
1967	4,781	2,735	57.2
1968	5,500	2,789	50.7
1969	5,587	2,676	47.9

Of course, students who qualify for engineering are qualified for many other university programs. The percentage entering engineering is not surprising, but the downward trend (over 9% in two years) is striking.

Flow into Engineering from Grade 12 Stocks

Uncertainties over the future of grade 13 led us to a consideration of students in grade 12 - where the total population has been reasonably stable and also relatively predictable through to 1979. Should grade 13 either discontinue or lose its significance during the 1970s, then all university students will be drawn from the grade 12 pool. If the four and five-year programs survive in some different form, then in all probability students destined for university will be drawn from the five-year program, and OISE has made a projection of this stream,[7] which is shown in Figure 3c.

Figure 11b is a plot of first-year engineering enrolment as a percentage of the total grade 12 enrolment two years before, for each academic (engineering) year from 1949-50 to 1969-70. As would be expected, its shape is similar to the grade 13 curve, except that it does not show the sharp jump in the last three

7 Cicely Watson, Saeed Quazi and Aubert Kleist, Ontario Secondary School Enrolment Projections, OISE Enrolment Projections No.5, 1969.

years exhibited by the grade 13 curve. In fact, a drop appears in 1967-68 when the impact of the Robarts Plan was felt by the universities. This was the start of a continuing downward trend, whereas the universities recovered the following year (see Figure 12b).

A subject analysis of grade 12 physics and chemistry would yield no meaningful results, because both subjects have been required for the successful completion of grade 12, and hence students have no choice.

First-Year University Enrolments

Now we examine the enrolment dynamics of those students who entered university. Unfortunately, for Ontario universities, freshman enrolments have been recorded only since 1959-60, so there is an inadequate time base to undertake more than a very short excursion into the future. Figure 3e shows total first-year university undergraduate enrolments for the fourteen provincially assisted universities, where they can be compared with freshman engineering and grade 13 enrolments. The only significant point about this curve is the drop in slope between 1966-67 and 1967-68, reflecting the drop in grade 13 enrolments the previous year.

Figure 12 shows a number of first-year enrolment ratios. Of particular interest is the rapid rise of 25% which occurred over a period of only four years (1965-1969), between the total of first-year university students as against the previous year's grade 13 number, again reflecting the changing composition of grade 13 (Figure 12a).

The curve of university freshman enrolment as a percentage of grade 12 enrolment two years earlier (Figure 12b) shows a less spectacular rise. The dip in 1967-68 is where the Robarts Plan affected the universities, from which they recovered in the following year. The projections beyond 1969-70 were made by OISE.[8]

Freshman enrolments contain students who do not enter directly from the Ontario high schools. This constituency includes adult students, advanced admissions and students from outside Ontario, and although the proportion is small, there are insufficient data to place a great amount of confidence in projections based on flows directly from the Ontario high schools.

Freshman engineering enrolment as a percentage of total university freshman enrolment is shown as Figure 12c. The downward trend is clear and, in fact, the extension of this curve would give the illusion that we will run out of freshman engineering students before the end of the 1970s. Aside from the short data base, the dynamic rates of change of the freshman enrolment ratios which, of necessity, must be short term, tend to swamp the engineering enrolment fluctuations so critical to a reasonable forecast. For these reasons, this method of using total university freshman enrolments has been rejected as a means of projection.

Total Enrolments

There has been a wealth of data on total enrolments in Ontario universities over the past twenty years, which gives considerable insight into the distribution dynamics within universities. An analysis was conducted of the distribution of total enrolment among the various faculties. This is shown in Figure 13. The width of each strip at any one point represents the percentage enrolment for each faculty of the total enrolment in that particular year. The play among arts,

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Watson and Quazi, Ontario University and College Enrolment Projections.

science and engineering is interesting. Arts has always been the largest faculty, and over the past fifteen years has moved from 35% to 50% of total enrolments. Over the same period, engineering and science taken together have grown far more slowly (from 23% to 29%). Yet the proportion of this band occupied by engineering in the mid-1950s was invaded by pure science in the late 1960s, so that science now is 17.7% of the total - exactly the same percentage as engineering in 1956! Engineering and science tend to draw from the same pool of high school students. When, then, did the swing away from engineering toward science occur, and how rapidly is it accelerating? To answer these questions, one has to turn to enrolments in science in relationship to the total university enrolment.

In Figure 1c, enrolments in science are plotted alongside enrolments in engineering. The reason for the dip in engineering in 1960-61 can be readily discerned. Prior to 1960 the percentage of enrolments in science remained relatively stable, growing from about 500 students in 1952 to just under 2,000 in 1959. A rapid rise began in 1960, with a doubling in two years, trebling in four, quadrupling in six, so that now it is over six times the enrolment in 1959. During this period grade 13 numbers were gaining even greater momentum, so that total engineering enrolments began to rise slowly again after 1963. Unfortunately, freshman enrolments in science are not readily available, so that a relative examination of student flows into engineering and science from grade 13 is not possible.

In Figure 14, parts a, b and c, the ratios of science and engineering to total university undergraduate enrolments are plotted separately and combined. (A recent estimate of university enrolments in Ontario to 1980-81[9] requires that Teachers' College enrolments, prior to 1968-69, be added to university undergraduate enrolments, in order to have a consistent base throughout the whole smoothing period. Total university enrolments in Figures 14 and 15 used this definition). Although the combined ratio shows reasonably smooth and steady growth (except for 1960-61), the growth in the

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[9] Zsigmond and Wenaas, Enrolment in Educational Institutions. Teachers' College enrolments prior to 1968-69 included some students who entered from grade 12, so that the corresponding total enrolments will tend to be slightly high. The effect on the forecast would be negligible.

science percentages coincides with the acceleration in the decline of engineering percentages. The science growth has continued its upward swing since 1960. The impact of the Robarts Plan created a deceleration of engineering first-year growth in 1967-68, (Figure 2), which affected second-, third- and fourth-year enrolments in subsequent years, and which, coupled with the swing from engineering to science, caused the deceleration of total engineering enrolments over the past two years.

A major turning point occurred in the late 1950s. Undoubtedly, this was caused by the Soviet Union's launching of Sputnik I in October 1957. The resulting immediate reform in United States science policy, with its tremendous push toward the pure sciences through the National Science Foundation and other federal agencies, and the attendant capture of the imagination of young people by the excitement of space science, created a swing in interest towards pure science with the impact on freshman engineering enrolments being felt in the United States the following September. A similar trend occurred in Canada, and freshman engineering enrolments in Ontario also show a drop in 1958 (Figure 2). The impact of this drop was felt in total engineering enrolments a few years later (Figure 1a).

Figure 15 contains plots of total university ratios on an expanded logarithmic scale for projection purposes. The ratio of engineering to total university enrolments has been plotted for a period of sixteen years from 1953-54 to 1969-70 (Figure 15a).

Since engineering students are predominantly male (over 99%), a smaller pool in university totals could be derived using only figures for male enrolments. Zsigmond and Wenaas have made a projection of male undergraduate numbers to 1980-81 as well as total undergraduate enrolments. The female proportion of total university undergraduate enrolment has been rising; it was 27% in 1951, 39% in 1969, and is estimated to be 42% by 1980. Elimination of this portion of the growth should enhance the accuracy of future projections, on the assumption that males continue to dominate engineering enrolments. The ratio of engineering to total university male enrolments also has been plotted in Figure 15b, with the same time base as the total male and female curve.

The Use of Demographic Data

One method often used for group projections is to analyze as a time series the percentage of the group in the relevant age bracket of the total population involved.

A recent study[10] has shown the age distribution of Ontario engineering students in 1968-69 to be as follows:

TABLE 5

AGE DISTRIBUTION OF ONTARIO ENGINEERING UNDERGRADUATES 1968-69

Age Range	No. Students (Undergraduate)
18-20	4,049
21-24	4,510
25-29	226
Over 29	83
	TOTAL 8,867*

*Total does not coincide with Table 1 for 1968-69; these data could be early fall registrations, and include part-time students.

Ontario is the only province in which the number of engineering students in the 21-24 age group exceeds the number in the 18-20 age group. Therefore, it is apparent that for engineering the appropriate age bracket is 18-24, and, for reasons stated earlier, the male portion of this age group has been used. The percentage of engineering undergraduates in this group is plotted in Figure 15c.

10 Post-Secondary Student Population Survey, 1968-69, Dominion Bureau of Statistics, Education Division, March, 1970

Enrolment Projections

We have seen that if entrance requirements for engineering are not altered, one faces the prospect of declining freshman enrolments (shown as the lower branch extension in Figure 17). CPUO has developed a statistical regression model wherein total enrolments can be derived from a history of first-year enrolments. This is described in the Appendix. Such a technique, applied over the past ten years, for which historical data are complete and reasonably accurate, shows remarkable consistency, with indices of determination exceeding 97%. Its validity over the next ten years cannot be as high because of the influx of the three-year CAAT technology graduates who are beginning to augment most second-year enrolments. Nevertheless, it is the best technique available, and has been utilized in the following translation between first-year and total enrolments. Its application to reverse projections, from total to first-year enrolments, has not been successful for the several reasons described in the Appendix. Therefore, such reverse projections have been conducted by an iterative process using the forward regression model, first-year to totals.

This regression model was used to derive total enrolments from the lower branch extension of freshman enrolments in Figure 17, and these are shown as the lower branch extension of the total enrolment curve.

We have viewed this approach as one that would yield the lowest and hence most pessimistic projection, and yet it could be reasonably accurate if entrance requirements into engineering are not altered. For the purposes of the next projection, we have assumed that new entrance requirements are set for engineering, similar to those for entrance into science which do not require specific subjects other than mathematics. Thus, there would be free and open play between enrolments in these two branches.

Based on this assumption, we now must speculate on future trends in the popularity of the two branches of science - pure and applied. The stock of young people entering pure science and engineering has been a rising proportion of total university stock (as is evident in Figure 14c), but an analysis of the popularity of science and mathematics subjects in grade 13 over the past fifteen years shows a general decline that must ultimately curtail this rise. Unfortunately, we do not have figures for the number of freshmen in pure science, so that an examination of relative first-year enrolments is not possible. Certainly, the engineering portion has been declining rapidly (Figure 12c), and the last point for 1969-70 on Figure 14c shows a drop in total science registration for the first time since 1960. For these reasons, we have assumed that total science enrolment saturates at about 26% of total university enrolments.

Pure science graduates generally move into either teaching or research careers. With a limited demand for teachers and relatively small expansion of research activities in Canada outside of the universities, it is unlikely that young people will continue to choose pure science at the increasing rate of the past ten years. On the other hand, over the next ten years we see no major reason why the proportion of engineering students should undergo any major trend changes, particularly if, as suggested above, the entrance requirements are altered but standards within the engineering schools are maintained.

Therefore, it would appear reasonable to extrapolate the ratio of total engineering enrolment to total university enrolment cver the next ten years, and this curve (Figure 14a), has been plotted in Figure 15a for this purpose. (Figure 15a extrapolates readily and is somewhat easier to work with than Figure 15b - the male-only curve).

From Figure 15a, an initial table of total engineering enrolments was developed using the Zsigmond and Wenaas projection for total university enrolment to 1980-81. An iterative procedure was then employed, using the regression model, to develop a first-year enrolment curve that best fits the total engineering enrolments derived from the trend line of Figure 15a. This projection was used for the latter portion beyond 1975.

It was possible to obtain an early indication of freshman engineering enrolments for 1970-71 (September 15), which was adjusted downward by 3% to account for normal attrition between mid-September and December 1, resulting in 2,750 freshmen. It would be necessary to have several years before the entrance requirement recommendations could affect enrolments. Therefore, a smooth transition was assumed between this figure for 1970 and the values derived beyond 1975, to produce the final freshman projection. The regression model then yielded the final total enrolment projection.

This table of engineering enrolments was used to extend the other curves in Figures 14 and 15, to ensure that they are reasonable and consistent. As is to be expected, the extension of the total university male curve, Figure 15 , falls within its trend envelope. The extension of the demographic curve, Figure 15c, using estimates by the Ontario Department of Treasury of the 18-24 male age group in Ontario, shows a slight drop below its trend envelope towards the end of the next decade. This would suggest that over this period these estimates may be somewhat low, if it is reasonable to assume that the proportion of male young people in this age group interested in engineering should follow the upward trend of the last twenty years. The attrition model only partially takes into account the recent trend of increasing CAAT diploma students entering at second year. This trend may well continue at an increasing pace, in which event the total projections would be pessimistic in the latter part of the 1970s.

Enrolments in science as a percentage of total university enrolments have been extended to 1980-81, using the above projection for engineering, in Figure 14b. This was derived by subtracting Figure 14a from Figure 14c. The rate of increase in science is shown to decline. In effect, the saturation of the combined curve (Figure 14c) is assumed to influence pure science far more than engineering, for the reasons stated earlier.

The first-year enrolment projections, constructed from the iteration described above, can now be tested both for validity and reasonableness. This was done using transitions from grade 13 and grade 12 stocks, and first-year university enrolment ratios. With the OISE projections to 1980-81 for high school enrolments, Figures 11a and 11b were extended using the final freshman enrolment iteration. Both these curves show remarkable consistency with the broad trend lines, extending back nearly twenty years.[11] First-year enrolment ratios were extended to 1976-77 in Figure 12c, using OISE projections for total university enrolments up to 1976. This extension, which indicates a levelling-off from the downward trend of the past seven years, could indicate that the projection may be optimistic. Of course, the only justification is the relief of entrance requirements which possibly would disturb this first-year trend and cause it to flatten out.

Conclusions

Two major kinds of influence factors underly this projection:

(1) Policy changes.

(2) Preference trends.

The major policy changes influencing enrolments have been:

(a) Introduction of the Robarts Plan in 1962 affecting grade 12 in 1965, grade 13 in 1966 and the universities in 1967.

(b) Introduction of the CAATs, and their expansion after 1966.

(c) Elimination of grade 13 departmental examinations in 1968.

The major preference trends influencing enrolments have been:

(a) The growth in the number of young people attending university. Over the past ten years, the university participation by young people in the 18-21 age group has grown from 11% to 21%.

(b) The swing away from physics and chemistry in the high schools after 1956.

(c) The swing toward pure science in the universities after 1960.

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11 The freshman enrolments in these projections would include adult students and advanced admissions, as well as students from outside the province. Thus, the actual flow directly from Ontario grade 13 would be somewhat lower than the projection shown in Figures 11a and 11b.

Certain of these preference trends may have been created by other policy changes. For example, the growth in the number of young people attending university has been made possible because of the expansion of university facilities, a policy decision brought about by public demand. The swing toward pure science in the universities was undoubtedly created by the impact of Sputnik and the ensuing support of pure science in the universities. The swing away from physics and chemistry cannot readily be traced to policy changes.

One other influencing factor that should be considered is the elasticity of the first-year and total engineering enrolments in response to economic factors such as changes in salaries for professional engineers.

In Figure 16, first-year engineering enrolments are compared with a number of economic factors: engineering starting salaries, GNP, capital investment and unemployment. It has been said that most economic factors can be correlated not only with each other but also with anything else one cares to select, and this certainly appears to be true here. The years 1955-1969 were selected to cover the period when engineering freshman enrolments dropped and then began to rise.

A cursory examination shows that the drop in 1958 coincided with a period of relatively high unemployment, and a decline in capital investment (including non-residential construction, new machinery and equipment) the previous year. Engineering starting salaries have been rising since 1955, and so there does not appear to be much correlation between salaries and enrolments. However, there is a closer relationship with the change in starting salaries, and this is plotted in Figure 16. During the period 1957-62, starting salaries moved upwards very slowly, but after 1962, they rose more rapidly along with the freshman enrolments.

Even if a good correlation could be found between enrolments and one or more of these economic factors, it would have little use in enrolment projections because of the uncertainties associated with the prediction into the future of these economic factors. We have concluded that this approach for enrolment projections has little value beyond that of broad interest.

Several studies[12] have been undertaken on why young people select engineering as a career. Among the main reasons cited, perhaps the most significant is the image of the profession itself. Much has been said elsewhere on this subject, so it is sufficient to state here that, over the past twenty years, little has occurred to change the image of the profession to attract more young people to it.

The above influence factors have been used in an attempt to explain the past enrolment fluctuations presented in Figures 1a and 2. Now, let us turn to possible future influence factors that may occur in the 1970s.

1. Policy Changes

   (a) Possible elimination of grade 13.

   (b) Major restructuring of the high school curriculum and alterations in high school science and mathematics programs.

   (c) Admission to engineering of students who have completed only four years of high school.

   (d) Alteration of admission requirements to engineering, particularly with respect to physics, chemistry and mathematics B, and restructuring the engineering curriculum to a more generalized form in the earlier years.

   (e) Establishment of quotas on university and/or engineering admissions (this would likely apply to certain universities, but not to others, so that places should always be available).

   (f) Policy changes in the profession which enhance its image in the eyes of young people.

2. Preference Trends

   (a) A continuation of the increasing percentage of high school graduates attending university.

   (b) A deceleration in the swing away from physics and chemistry in the high schools.

   (c) A swing back to engineering from the pure sciences in the universities.

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[12] R.P. Loomba, An Examination of the Engineering Profession, Manpower Research Group, Center for Interdisciplinary Studies, San Jose State College, September 1968; and

Factors Influencing Engineering Enrolment, ECAC Committee for the Analysis of Engineering Enrolment, American Society for Engineering Education, 1965.

In evaluating which of these influence factors are most likely to occur, we have assumed that the policy changes suggested above will take place in the 1970s, and this would imply that the preference trends cited are likely to occur.

Throughout, it has been tacitly assumed that future enrolments will be determined solely by social demand for places, and in no way controlled by the requirements for engineers in Ontario or in Canada, or by cost/benefit considerations. The introduction of such factors cannot be justified until far more sophisticated models[13] of the total educational system are developed, and such models are woven into the fabric of our educational planning processes. Meanwhile, our planning is based strictly on the anticipated social demand for student places, and this is the <u>only</u> criterion applied here.

The method employed for the final projection depends upon the validity of the Zsigmond and Wenaas projections of total university enrolment to 1980-81. It has been suggested that these are on the high side, showing an Ontario increase in the ten year period 1970-80 of nearly 2.2:1. The increase of young people in the 18-21 year age group (total university stocks are mainly from this group) in Ontario has been predicted as increasing by only 1.2:1 over this same period. Consequently, this projection presumes that the university participation rate of this group will increase from a current one person in five in 1970 to one person in three by 1980. This may not be too unreasonable, considering the increase in the rate of participation over the past twenty years, as shown in Table 2.

The assumption that entrance requirements for engineering will be altered still begs the question: <u>how</u> should they be altered? So far, we have assumed that they should be the same as the entrance requirements for science in each university. The need for this can be illustrated using Table 6:

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[13] P. Armitage, C. Smith and P. Alper, <u>Decision Models for Academic Planning</u>, LSE Studies on Education (London; The Penguin Press, 1969).

TABLE 6

GRADE 13 STUDENTS QUALIFIED TO ENTER ENGINEERING

Year	Number of Grade 13 Students Qualified to enter Engineering as a Percentage of Passes in:		
	Physics	Chemistry	Math B.
1967-68	43.6	26.5	51.1
1968-69	28.1	32.3	55.6
1969-70	44.8	31.4	52.6

Mathematics B might have been used as the limiting factor for engineering enrolments, but was not selected because of the short history for this subject, which started only in 1967.

If either mathematics B or physics were removed as a requirement, the other would still be a limiting factor on the number qualified. Chemistry is less critical, but would still provide a severe restriction. There would appear to be a good case for removing all entrance requirements except for, say, mathematics A and one science, together with a minimum overall standing. Such a policy would make it possible for one-half of the grade 13 population to choose engineering. A student who chooses engineering is likely to have a reasonable mixture of the subjects required heretofore, and moreover, the need for make-up classes may have to become standard in all of the engineering schools, owing to the changing structure of the high schools.

Such a policy would undoubtedly create increased attrition in the first year, thereby increasing costs and invalidating the attrition model used in these projections. However, there seems to be little alternative, for as the high schools alter their structure, major revisions will be required in the first year. The increased attrition caused by such a policy has a compensating factor, in that increasing numbers of three-year CAAT graduates should be entering the second year of engineering. Although these work in opposite directions, there is no reason to believe they will compensate perfectly. We can fall back on the demographic curve (Figure 14c) and infer that, if anything, the projection for the latter part of the next decade appears to be somewhat low.

The final projection of engineering enrolments is presented in Table 7, together with a rough estimate of the error inherent in this estimate, and summarized in Figure 17. Included in Figure 17 are the universities' projections, taken from their submissions. These were presumably based on a continuation of current entrance requirements, standards and practices.

TABLE 7

TOTAL FULL-TIME UNDERGRADUATE ENGINEERING ENROLMENT PROJECTIONS
PROVINCIALLY-ASSISTED ONTARIO UNIVERSITIES
FIRST -YEAR AND TOTAL ENROLMENT TO 1980-81

FINAL SELECTION

Year	First-Year		Total	
	Projection	Uncertainty	Projection	Uncertainty
1970-71	2,750	+ 0 - 10%	8,620	+ 0 - 5%
1971-72	2,970		8,948	
1972-73	3,290		9,401	
1973-74	3,500		10,061	
1974-75	3,610		10,672	
1975-76	3,695	± 10%	11,247	± 10%
1976-77	3,780		11,763	
1977-78	3,855		12,166	
1978-79	3,915		12,466	
1979-80	3,970		12,712	
1980-81	4,040		12,950	

Finally, it is possible to make a rough comparison between the degree output anticipated from this enrolment projection and the requirement for engineers as generated by Skolnik and McMullen.[14] Their study

[14] M. Skolnik and W. McMullen, "An Analysis of Projections of the Demand for Engineers in Canada and Ontario and An Inquiry into Substitution Between Engineers and Technologists." (Toronto: CPUO Report No. 70-2 November 1970).

concluded, quite independently, that the required flow of engineers from the Ontario schools should be about 1,700 bachelors per year over the fourteen-year period 1968-81. The attrition model was extended to include bachelor degree production, using the history of degree output presented in the submissions from the Ontario engineering schools. This is summarized in Table 8.

TABLE 8

PROJECTED ENGINEERING BACHELOR'S DEGREE OUTPUT
PROVINCIALLY-ASSISTED UNIVERSITIES, ONTARIO, 1968-1981

Year	··ıgineering Bachelor's Degrees	Cumulative Average Degrees/Year
1968	991	991
1969	1,170	1,081
1970	1,416	1,192
1971	1,540	1,279
1972	1,664	1,356
1973	1,558	1,390
1974	1,639	1,425
1975	1,717	1,462
1976	1,848	1,505
1977	2,020	1,556
1978	2,163	1,611
1979	2,253	1,665
1980	2,315	1,715
1981	2,368	1,762

It is projected that by 1981, an average of 1,762 engineering bachelor's degrees will be awarded annually by the Ontario provincially-assisted universities, as against an anticipated requirement of 1,700 graduates a year. In view of the inherent uncertainties in both these figures, the output of engineers related to the enrolment projection would appear to satisfy the basic requirements for engineers from the Ontario universities over the next decade.

We conclude by suggesting that entrance policies should be altered so as to ensure that the growth of enrolments as indicated in Table 7 is met as closely as possible. This alteration should be designed to remove the barriers created by the declining interest in the physical sciences as taught in the high schools, but the required grade-point average must be such as to maintain the academic quality of engineering candidates. This will be accompanied by increased costs due to greater first-year attrition, but such increases can be offset by larger enrolments in the smaller schools, which should reduce their unit costs.

A P P E N D I X

THE ATTRITION MODEL

by

IVOR W. THOMPSON and JOHN J. LONG

In developing enrolment projections for engineering programs in the Ontario universities it was necessary to have the capacity to derive either total enrolments from projections of first-year enrolments or freshman enrolments from projections of total enrolments. Given a historical data base of the flow of individual students through the system, a transition matrix of the following form could have been constructed where a_{ij} represents the proportion of students in state i at time t who move to state j at time t + 1.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1i} \\ \cdot & & & \\ a_{21} & & & \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ a_{i1} & \cdots & \cdots & a_{ii} \end{bmatrix}$$

NOTATION
1. Non-subscripted capital letters refer to matrices.
2. Subscripted letters refer to elements of the matrix with the corresponding capital letter.

For an engineering program of four years' duration, matrix A would logically have positive elements on the main and super diagonals and zero elements elsewhere (matrix B).

$$B = \begin{bmatrix} 0.15 & 0.70 & 0 & 0 \\ 0 & 0.10 & 0.80 & 0 \\ 0 & 0 & 0.05 & 0.90 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Thus element b_{12} can be interpreted as "70% of all students in first year graduate to second year." However, information on the flow of students in a system is usually not available to construct this form of transition matrix. Instead, only stock data are readily available: the number of students in state i at time t.

However, an approximation to matrix B can be constructed in which flows are assumed from the stock data. One such approximation (matrix C) consists of positive elements only on the super diagonal.

$$C = \begin{bmatrix} 0 & 0.75 & 0 & 0 \\ 0 & 0 & 0.85 & 0 \\ 0 & 0 & 0 & 0.92 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

In this approximation the elements of the super diagonal are often greater than the corresponding elements of the transition matrix derived from actual flow data (cf. matrix B). It is assumed that no students remain in a given year for longer than one time period but either graduate to the next level or are lost to the system. Given the matrices E (the enrolment by year), P (the transition matrix), and F (the net inflow of students into the system), then:

$$E(t) = F(t) + PE(t-1) \qquad (1)$$

$$\begin{bmatrix} e_1(t) \\ \vdots \\ e_4(t) \end{bmatrix} = \begin{bmatrix} f_1(t) \\ \vdots \\ f_4(t) \end{bmatrix} + \begin{bmatrix} p_{11} \cdots p_{14} \\ \\ p_{41} \cdots p_{44} \end{bmatrix} \begin{bmatrix} e_1(t-1) \\ \vdots \\ e_4(t-1) \end{bmatrix}$$

where: $e_i(t)$ = enrolment in year i at time t,

$f_i(t)$ = net inflow of students into year i from outside the system at time t,

p_{ij} = proportion of students moving from year i to year j. All elements of p are assumed constant over time, and

$$E_T(t) = \sum_{i=1}^{4} e_i(t)$$

where $E_T(t)$ = total enrolment, summed over the four years, at time t.

Submissions from the Ontario engineering schools contained data on enrolments in each year of each program over the period 1960-61 to 1969-70. From these data it was possible to construct a matrix of the form C. Application of this transition matrix would produce adequate projections if the transition proportions p_{ij} remained relatively constant over the period under study. However, examination of the data revealed that these proportions did not remain constant from one year to the next but appeared to change with the rate of enrolment growth.

Therefore, two additional factors were added to account for these variations in the transition proportions. These changes were not made to affect the transition proportions directly but rather to be added as compensating factors to the resulting stocks.

It was assumed that the enrolment in any session (t)is linearly related to the enrolment in the previous session (t - 1) and to the absolute rate of change of enrolment from session(t - 2) to(t - 1) .

$$E(t) = A + F(t) + PE(t-1) + C\left|E(t-1) - E(t-2)\right| \quad (2)$$

$$E_T(t) = \sum_{i=1}^{4} e_i(t) \quad (3)$$

where: A = matrix of constant terms a_i , i = 1,4

C = matrix of elements c_{ij}, i = 1,4 j = 1,4

$$C_{ij} = 0 \text{ for all } j \neq i + 1$$

For this model all elements of F(t), except $f_1(t)$, were considered equal to zero. The elements of matrices A, P and C were determined by applying a step-wise linear regression to the historical enrolment structure. Because of the compensating factors, elements of the transition matrix may exceed unity. The results are listed in Table A-1.

TABLE A-1

PARAMETERS OF THE ATTRITION MODEL

i	a_i	$p_{i,i+1}$	c_i	CORRELATION COEFFICIENT	ESTIMATED STANDARD ERROR OF $e_i(t)$
1	0.0	0.0	0.0	-	-
2	-352.6	1.042	-0.502	0.998	44.1
3	187.4	0.686	-0.370	0.988	65.2
4	- 12.3	0.949	-0.067	0.997	24.5

To test the model, freshman enrolments were applied to equation (2) to develop the terms for equation (3). Freshman enrolments for six previous years are required to develop all the terms. The results of this test are presented in Table A-2.

TABLE A-2

TOTAL ENGINEERING ENROLMENT

	1966-67	1967-68	1968-69	1969-70
MODEL	6,436	7,260	7,945	8,360
ACTUAL	6,415	7,218	8,002	8,502
PERCENTAGE DIFFERENCE	+ 0.3	+ 0.6	- 0.7	- 1.7

The model would appear to yield slightly lower enrolments in the last two years, which could be the influence of diploma technology graduates entering at the second-year level. This could be corrected by inserting appropriate values in the $f_2(t)$ element of the F matrix to account for the incoming CAAT students.

An attempt was made to operate the attrition model in reverse, that is to develop first-year enrolments from total enrolments. The difficulty arose in the absolute term in equation (2). It was found easier to use the forward attrition model developed above, and thus determine first-year enrolments by an iterative process (the determination of a set of first-year enrolment figures which, translated through the model, matches the given set of total enrolment figures).

Finally, a simple model for estimating bachelor degree output was constructed by using a simple linear regression relating the degrees awarded in session t, d(t), to fourth-year enrolment, $e_4(t)$:

$$d(t) = -36.33 + 0.976\, e_4(t) \qquad (4)$$

FIGURE 1

TOTAL UNDERGRADUATE ENROLMENTS - ONTARIO

Academic Year	(a) Total Engineering Enrolment	(b) 18-21 Age Group	(c) Total Science Enrolment
1941-42	1,719		
42-43	2,008		
43-44	1,739		
44-45	1,711		
45-46	2,435		
46-47	5,642		
47-48	5,610		
48-49	5,110		
49-50	3,908		
50-51	2,917		
51-52	2,346	264,300	
52-53	2,410	267,500	523
53-54	2,591	270,400	886
54-55	2,938	273,000	931
55-56	3,132	275,200	1,017
56-57	3,416	276,600	1,131
57-58	3,860	281,400	1,452
58-59	4,123	287,800	1,564
59-60	4,220	296,700	1,770
60-61	3,791	306,400	2,239
61-62	3,823	316,800	3,571
62-63	3,922	335,000	4,123
63-64	4,401	354,500	4,783
64-65	4,894	379,500	5,719
65-66	5,685	412,800	6,854
66-67	6,415	431,600	8,952
67-68	7,218	461,500	10,935
68-69	8,002	487,200	14,799
69-70	8,502	508,400	15,726
70-71		526,800	
71-72		541,300	
72-73		555,600	
73-74		571,800	
74-75		589,500	
75-76		608,200	
76-77		626,700	
77-78		643,200	
78-79		657,100	
79-80		667,700	
80-81		672,000	

Figure 1 — TOTAL UNDERGRADUATE ENROLMENTS — ONTARIO

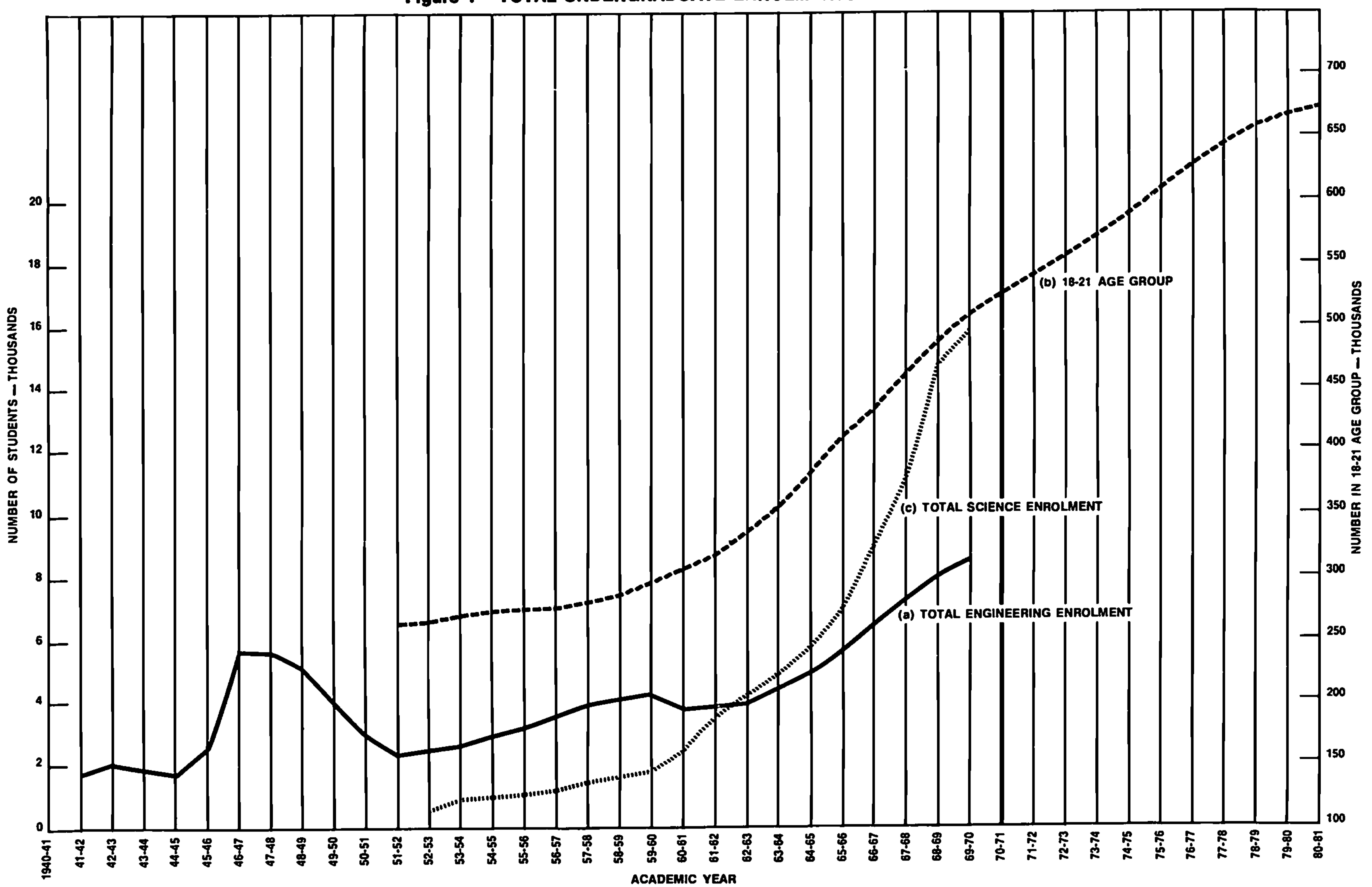


FIGURE 2

FIRST YEAR ENGINEERING ENROLMENT - ONTARIO

Academic Year	First Year Engineering
1941-42	670
42-43	818
43-44	563
44-45	596
45-46	742
46-47	2,367
47-48	1,477
48-49	836
49-50	679
50-51	664
51-52	723
52-53	923
53-54	894
54-55	1,058
55-56	1,046
56-57	1,187
57-58	1,431
58-59	1,372
59-60	1,247
60-61	1,213
61-62	1,284
62-63	1,470
63-64	1,706
64-65	1,870
65-66	2,233
66-67	2,581
67-68	2,735
68-69	2,789
69-70	2,676

Figure 2 — FIRST-YEAR ENGINEERING ENROLMENT — ONTARIO

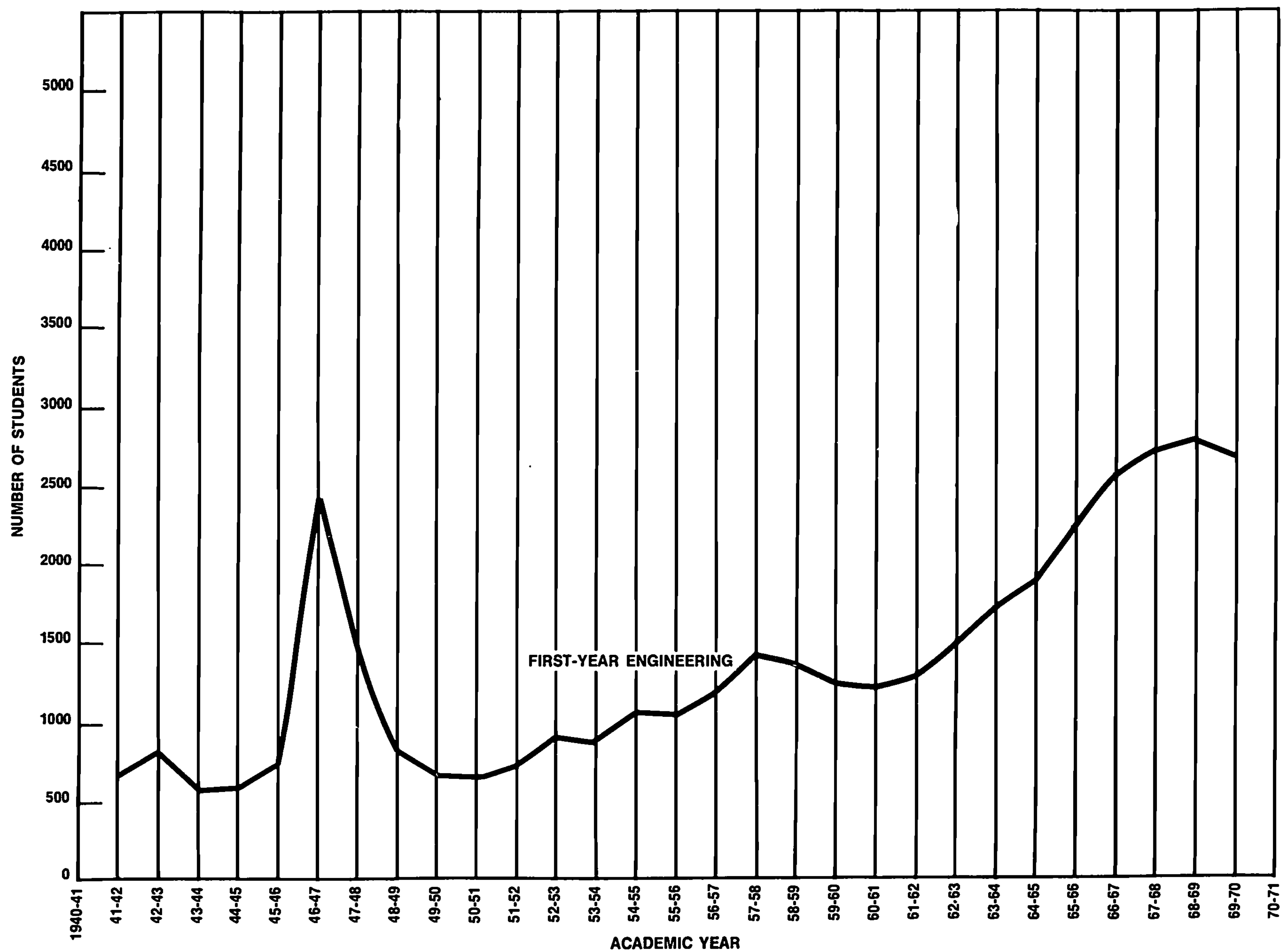


FIGURE 3

ONTARIO SECONDARY SCHOOL ENROLMENTS

Academic Year	(a) Total Grade 12	(b) Total Grade 13	(c) Grade 12 Five Year Program	(d) First Year CAATs	(e) Total First Year - Ontario Universities
1929-30		5,051			
30-34*					
34-35		8,268			
35-39*					
39-40		7,805			
40-44*					
44-45		8,022			
45-46		9,412			
46-47		9,430			
47-48		9,343			
48-49		9,506			
49-50		9,660			
50-51		9,457			
51-52		8,827			
52-53		8,975			
53-54		9,472			
54-55		9,981			
55-56		10,799			
56-57	25,041	11,487			
57-58	26,769	12,547			
58-59	31,058	14,278			
59-60	34,792	16,267			6,839
60-61	38,697	18,447			8,345
61-62	42,266	21,482			8,676
62-63	46,776	23,750			10,006
63-64	52,746	26,262	42,446		12,164
64-65	60,797	32,770	47,523		13,552
65-66	67,282	37,692	43,638		16,650
66-67	70,625	35,007	44,779		20,462
67-68	75,214	36,472	46,507	8,249	22,000
68-69	82,371	40,167	50,343	12,330	26,558
69-70	92,080	43,569	55,481	14,717	30,737
70-71	101,400	48,340	60,732	16,886	34,157
71-72	109,860	52,830	67,226	18,857	37,123
72-73	116,550	56,800	71,348	20,814	39,901
73-74	121,570	59,800	74,027	22,844	41,488
74-75	126,240	61,880	76,379	24,976	41,728
75-76	130,900	63,750	79,219	27,191	42,024
76-77	134,490	66,100	81,396	29,496	42,704
77-78	138,530	67,920	83,838	31,783	
78-79	141,040	69,960	85,337	34,009	
79-80	143,560	71,220	86,833	36,124	
80-81	144,110	72,500		37,935	

* Data not available for intervening years.

Figure 3 — ONTARIO SECONDARY SCHOOL ENROLMENTS

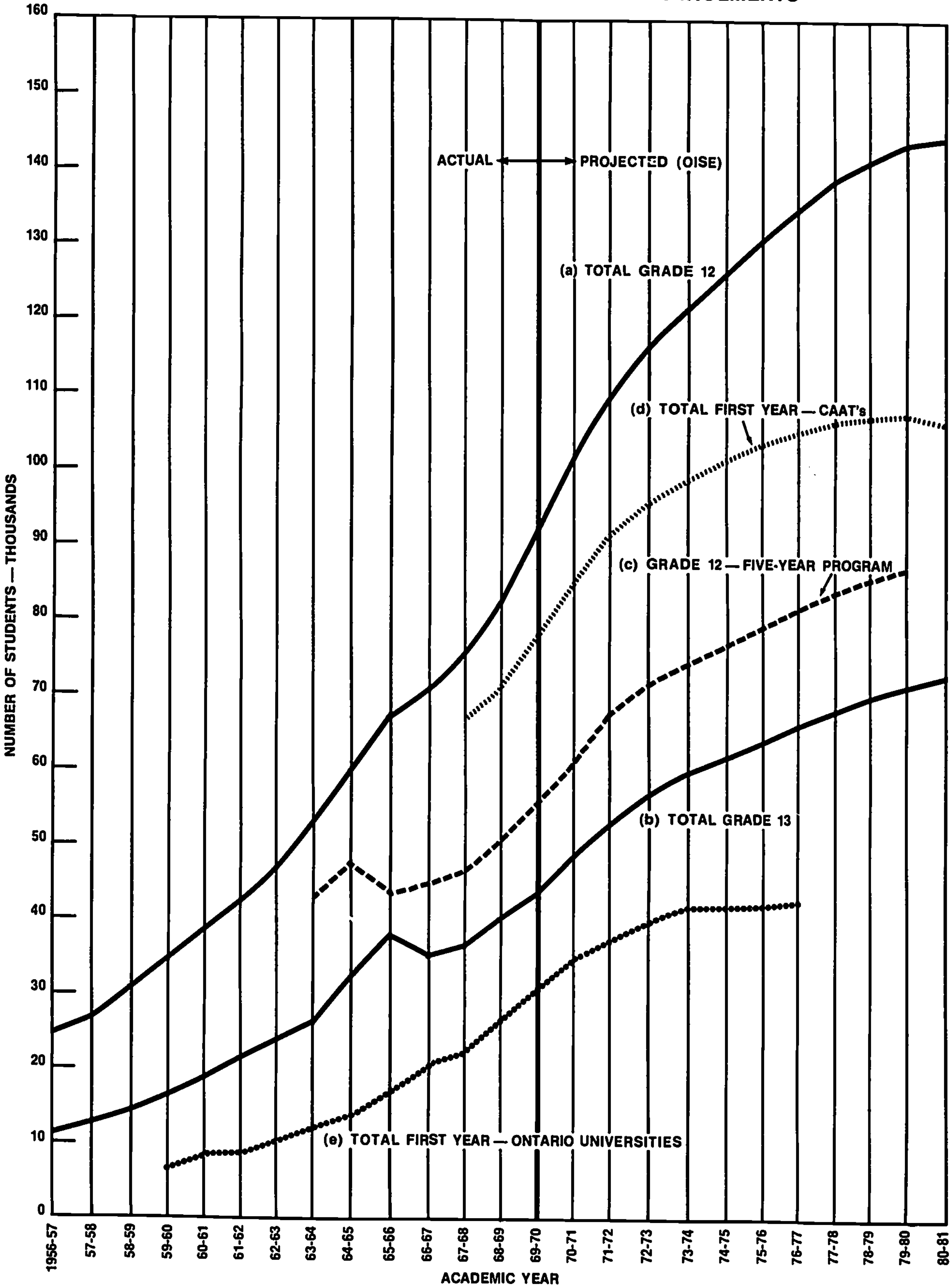


FIGURE 4

THE SCIENCES - GRADE 13 DEPARTMENTAL EXAMINATIONS
NUMBER OF STUDENTS ACHIEVING PASS - 50% OR BETTER

Academic Year	Physics	Chemistry	Botany	Zoology	Biology
1929-30	1,662	1,221	574	658	
30-34*					
34-35	2,511	2,643	1,726	1,753	
35-39*					
39-40	2,935	2,877	2,328	2,343	
40-44*					
44-45	3,634	4,344	2,890	3,164	
45-46*					
46-47	4,074	4,985	3,414	3,380	
47-48	3,969	5,250	3,127	3,108	
48-49	4,408	5,234	3,444	3,238	
49-50	4,475	4,996	3,107	3,344	
50-51	4,127	5,141	3,289	3,318	
51-52	4,137	5,024	2,962	3,351	
52-53	4,106	5,026	2,995	3,352	
53-54	4,450	5,321	3,268	3,639	
54-55	4,661	5,729	3,445	3,854	
55-56	4,541	6,434	3,884	4,424	
56-57*					
57-58	5,896	6,880	4,026	5,300	
58-59	5,654	7,924	5,029	6,214	
59-60	6,800	7,775	6,193	7,405	
60-61	7,301	9,891	7,257	9,019	
61-62	8,316	10,368	8,353	9,236	
62-63	8,265	11,605	9,771	11,588	
63-64	9,317	12,622	10,730	12,384	
64-65	11,496	16,157	13,184	15,360	
65-66	11,996	19,568			16,668
66-67	10,919	17,388			13,563
67-68	10,967	18,013			16,667
68-69	11,429	17,010			18,870
69-70	12,452	17,795			21,297

* Data not available for intervening years.

Figure 4 — THE SCIENCES — GRADE 13 DEPARTMENTAL EXAMINATIONS
NUMBER OF STUDENTS ACHIEVING PASS — 50% OR BETTER

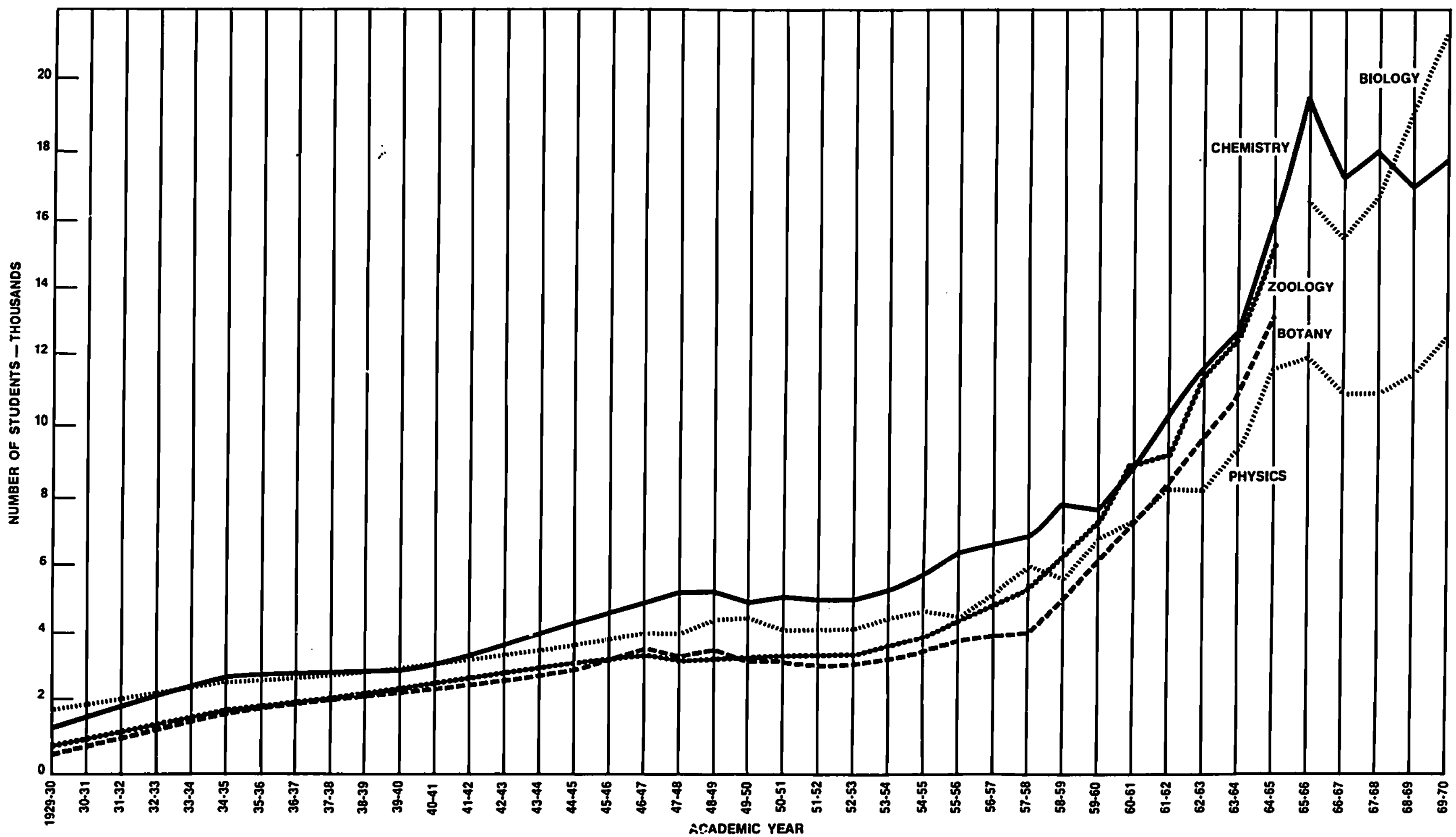


FIGURE 5

MATHEMATICS - GRADE 13 DEPARTMENTAL EXAMINATIONS
PERCENTAGE OF GRADE 13 STUDENTS ACHIEVING PASS - 50% OR BETTER

Academic Year	Algebra	Geometry	Trigonometry	Mathematics B	Mathematics A
1929-30	63.79	68.11	68.14		
30-34*					
34-35	48.60	59.16	68.86		
35-39*					
39-40	45.18	59.27	63.24		
40-44*					
44-45	45.03	60.82	63.66		
45-46*					
46-47	44.63	55.06	51.25		
47-48	46.81	62.29	55.35		
48-49	46.63	60.33	49.37		
49-50	47.46	54.35	56.25		
50-51	47.41	58.08	49.48		
51-52	50.42	61.87	55.44		
52-53	47.22	59.94	54.75		
53-54	52.87	65.33	59.33		
54-55	45.99	65.41	53.20		
55-56	54.05	59.75	61.70		
56-57*					
57-58	48.10	58.12	56.05		
58-59	47.99	53.80	54.01		
59-60	52.92	58.54	57.08		
60-61	51.18	61.34	54.81		
61-62	46.76	53.77	50.08		
62-63	48.05	54.65	48.90		
63-64	47.52	54.52	50.00		
64-65	46.87	52.97	49.08		
65-66	52.00	58.69	54.46		
66-67				26.71	60.75
67-68				27.12	63.97
68-69				26.37	64.50
69-70				25.50	64.60

* Data not available for intervening years.

Figure 5 — MATHEMATICS — GRADE 13 DEPARTMENTAL EXAMINATIONS
PERCENTAGE OF GRADE 13 STUDENTS ACHIEVING PASS — 50% OR BETTER

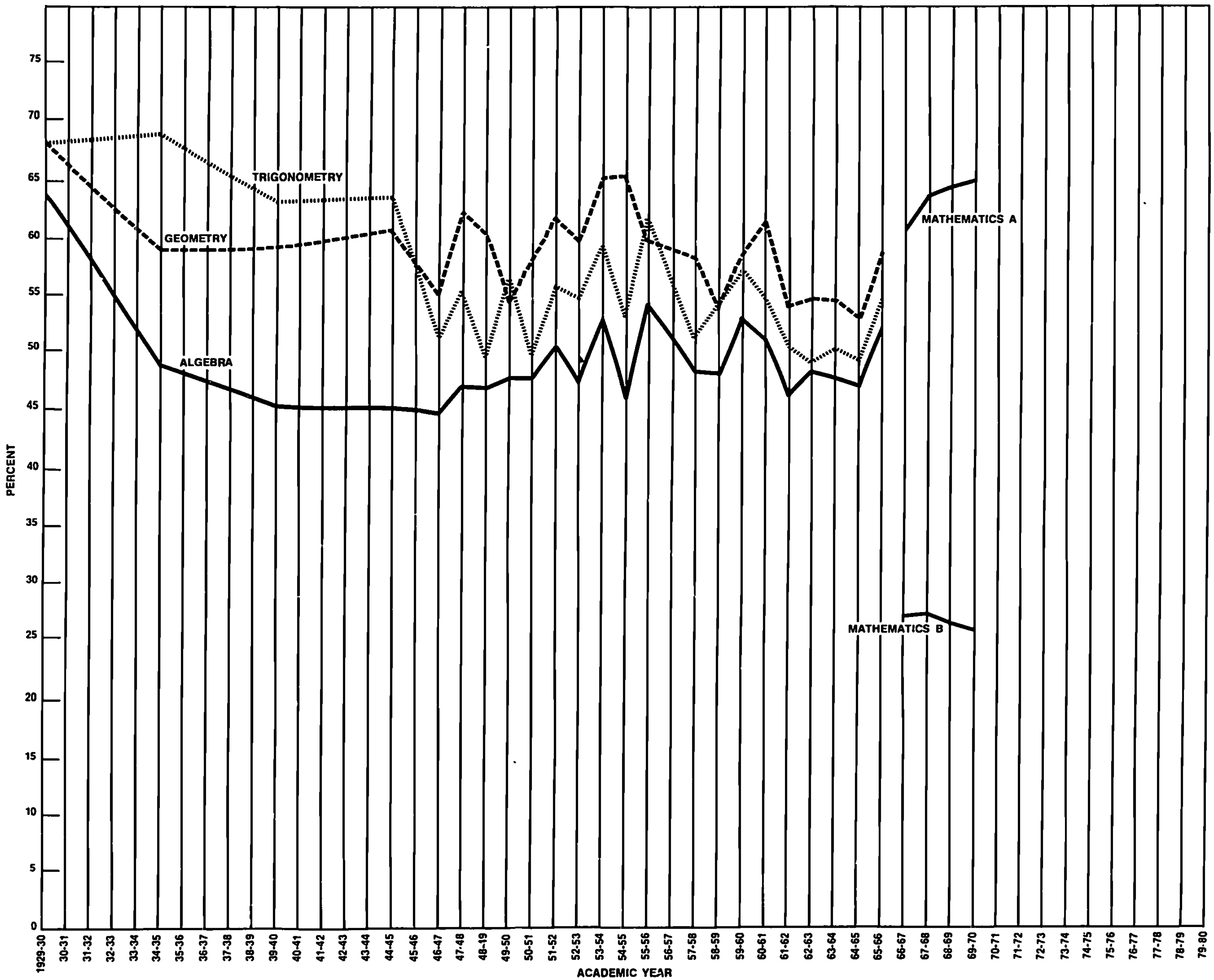


FIGURE 6

PHYSICS AND CHEMISTRY - GRADE 13 DEPARTMENTAL EXAMINATIONS
PERCENTAGE OF GRADE 13 STUDENTS ACHIEVING PASS - 50% OR BETTER

Academic Year	Physics	Chemistry
1929-30	32.90	24.17
30-34*		
34-35	30.37	31.97
35-39*		
39-40	37.60	36.86
40-44*		
44-45	45.30	54.15
45-46*		
46-47	43.20	52.86
47-48	42.48	56.19
48-49	46.37	55.06
49-50	46.33	51.72
50-51	43.64	54.36
51-52	46.87	56.92
52-53	45.75	56.00
53-54	46.98	56.18
54-55	46.70	57.39
55-56	42.05	59.58
56-57*		
57-58	46.99	54.83
58-59	39.60	55.50
59-60	41.80	47.80
60-61	39.58	56.62
61-62	38.71	48.26
62-63	34.80	48.86
63-64	35.48	48.06
64-65	35.08	49.30
65-66	31.82	51.92
66-67	31.19	49.67
67-68	30.07	49.39
68-69	28.45	42.35
69-70	28.58	40.84

* Data not available for intervening years.

Figure 6 — PHYSICS AND CHEMISTRY — GRADE 13 DEPARTMENTAL EXAMINATIONS
PERCENTAGE OF GRADE 13 STUDENTS ACHIEVING PASS — 50% OR BETTER

FIGURE 7

GRADE 13 PHYSICS PERFORMANCE STANDINGS
ACHIEVED AS A PERCENTAGE OF GRADE 13 ENROLMANT

Academic Year	Failures	Credits	Third Class Honours	Second Class Honours	First Class Honours
1959-60	9.9	25.5	33.0	43.3	51.7
60-61*					
61-62	8.3	24.5	32.2	38.3	47.0
62-63	8.5	21.3	29.0	36.3	43.3
63-64	7.8	21.0	28.3	34.8	43.2
64-65	7.5	20.5	28.0	35.4	42.6
65-66	5.3	16.9	23.8	29.5	37.1
66-67	3.1	11.9	18.1	26.0	34.3
67-68	3.6	12.2	18.6	26.3	33.6
68-69	2.9	10.4	16.6	23.8	30.6

* Data not available for intervening years.

Figure 7 — GRADE 13 PHYSICS PERFORMANCE STANDINGS ACHIEVED AS A PERCENTAGE OF GRADE 13 ENROLMENT

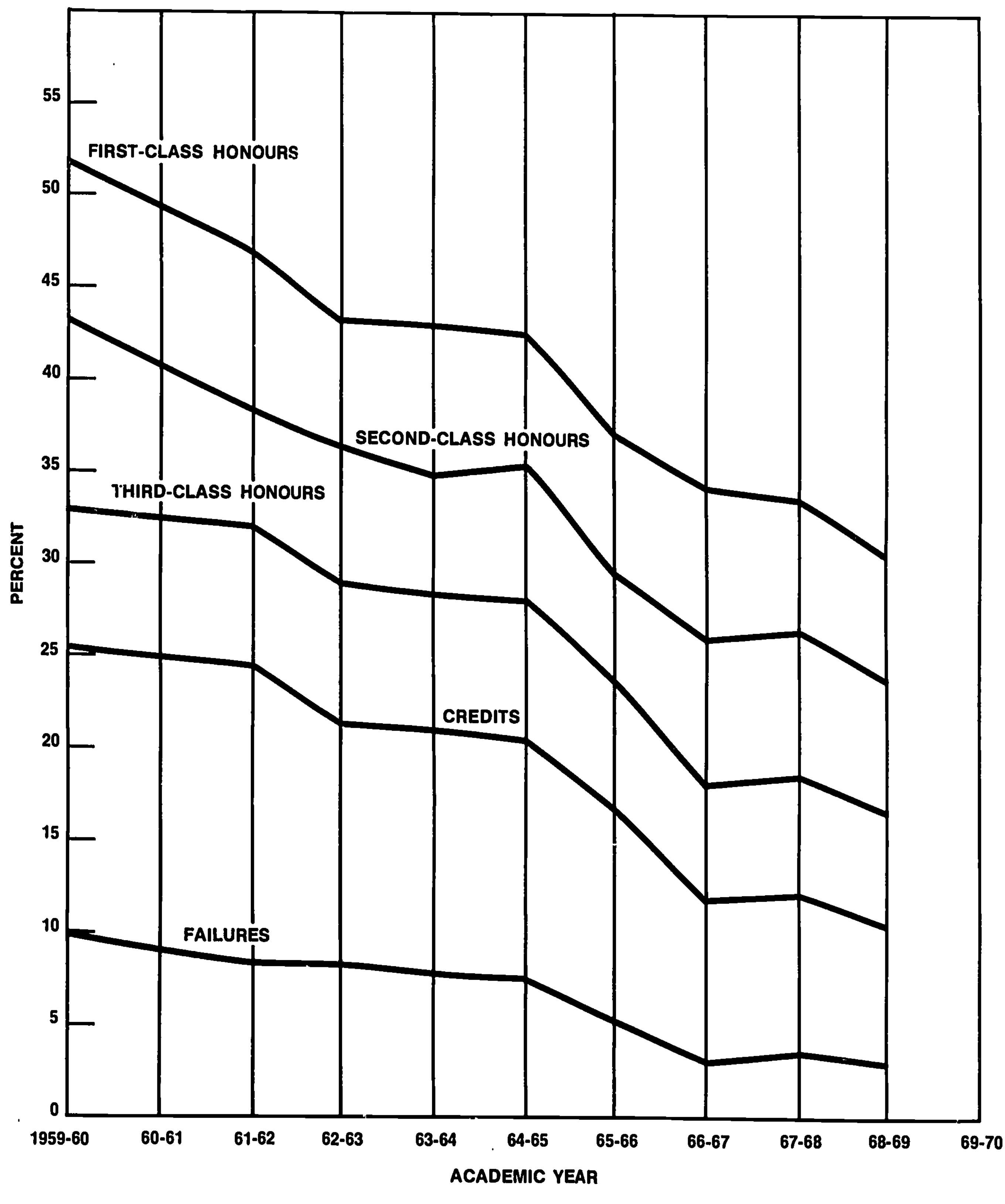


FIGURE 8

ONTARIO AND UNITED KINGDOM

A COMPARISON OF STUDENTS ACHIEVING PASS STANDING OR BETTER ON LEAVING SECONDARY EDUCATION AS A PERCENTAGE OF FINAL YEAR ENROLMENTS - SELECTED SUBJECTS

Academic Year	Ontario Geometry	Ontario Trigonometry	Ontario Algebra	Ontario Physics	U.K. Mathematics	U.K. Physics	U.K. Chemistry
1960-61	61.34	54.81	51.18	39.58			
61-62	53.77	50.08	46.76	38.71	48.95	38.28	29.52
62-63	54.65	48.90	48.05	34.80	47.69	36.35	28.41
63-64	54.52	50.00	47.52	35.48	44.11	34.40	25.50
64-65	52.97	49.08	46.87	35.08	44.17	31.58	23.00
65-66	58.69	54.46	52.00	31.82	42.21	29.57	22.35

Figure 8 — ONTARIO AND UNITED KINGDOM
A Comparison of Students Achieving Pass Standing or Better on Leaving Secondary Education as a Percentage of Final-Year Enrolments — Selected Subjects.

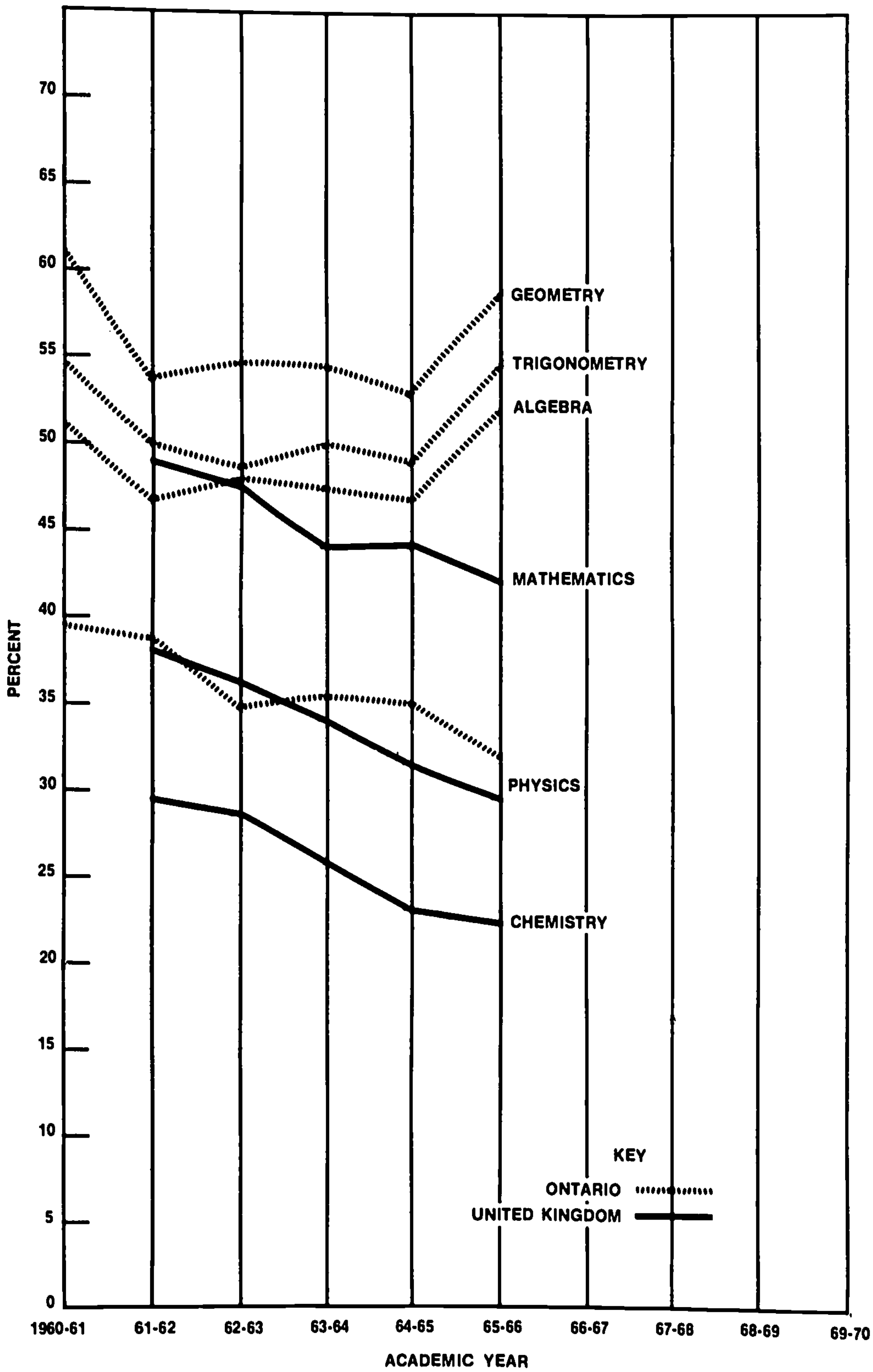


FIGURE 9

LIFE SCIENCES - GRADE 13 DEPARTMENTAL EXAMINATIONS
PERCENTAGE OF GRADE 13 STUDENTS ACHIEVING PASS - 50% OR BETTER

Academic Year	Botany	Zoology	Biology
1929-30	11.4	13.0	
30-34*			
34-35	20.9	21.2	
35-39*			
39-40	29.8	30.0	
40-44*			
44-45	36.0	39.4	
45-46*			
46-47	36.2	35.8	
47-48	33.5	33.3	
48-49	36.2	34.1	
49-50	32.2	34.6	
50-51	34.8	35.1	
51-52	33.6	38.0	
52-53	33.4	37.3	
53-54	34.5	38.4	
54-55	34.5	38.6	
55-56	36.0	41.0	
56-57*			
57-58	32.1	42.2	
58-59	35.2	43.5	
59-60	38.1	45.5	
60-61	39.3	48.9	
61-62	38.9	43.0	
62-63	41.1	48.8	
63-64	40.9	47.2	
64-65	40.2	46.9	
65-66			44.2
66-67			38.7
67-68			45.7
68-69			47.0
69-70			48.9

* Data not available for intervening years.

Figure 9 — LIFE SCIENCES — GRADE 13 DEPARTMENTAL EXAMINATIONS PERCENTAGE OF GRADE 13 STUDENTS ACHIEVING PASS — 50% OR BETTER

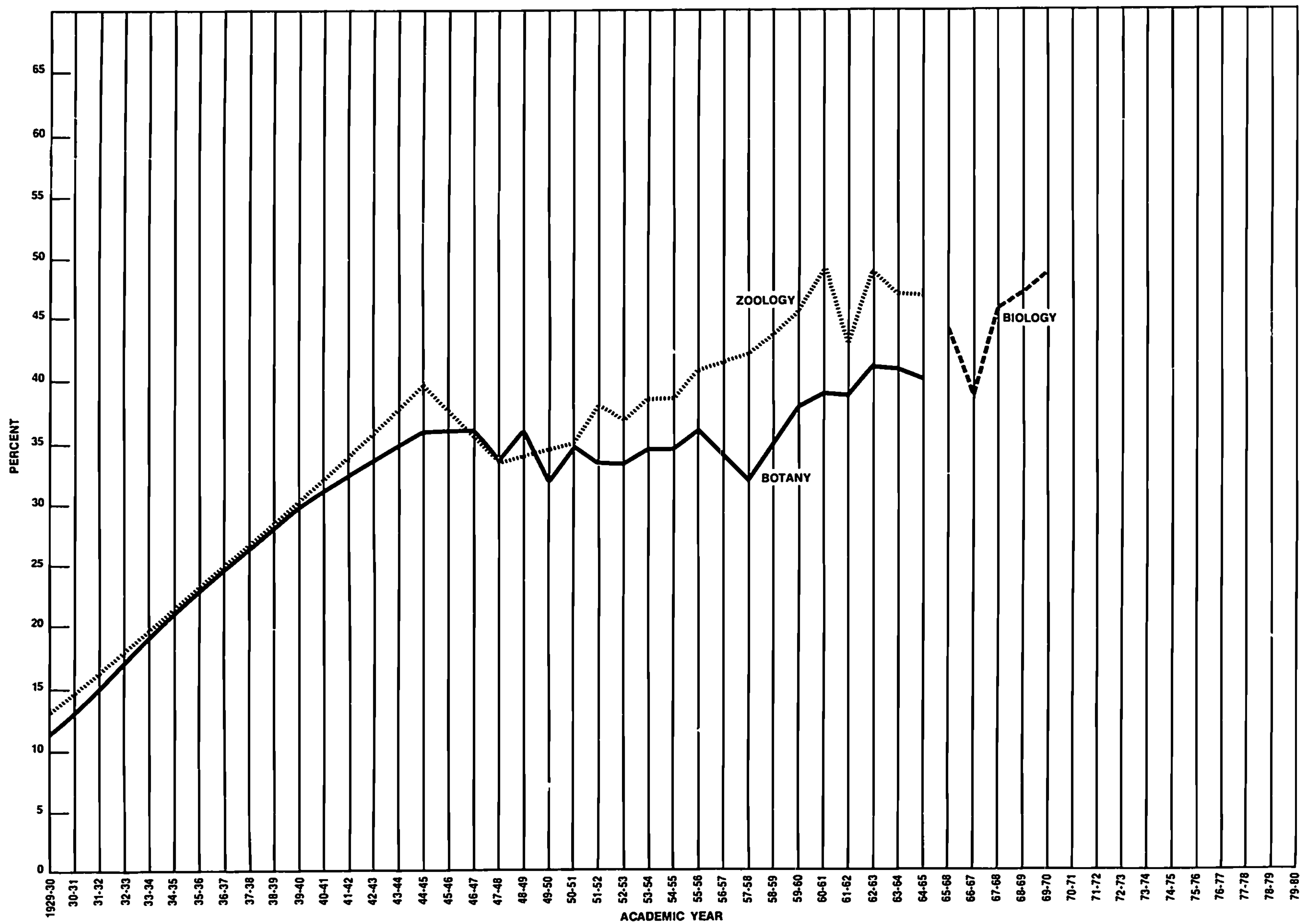


FIGURE 10

FIRST YEAR ENGINEERING FALL ENROLMENT AS A PERCENTAGE OF STUDENTS ACHIEVING PASS - 50% OR BETTER - IN PHYSICS AND CHEMISTRY IN THE PREVIOUS SPRING DEPARTMENTAL EXAMINATIONS

Academic Year	(a) Physics	(b) Chemistry
1945-46	20.42	17.1
46-47*		
47-48	36.25	29.6
48-49	21.06	15.9
49-50	15.40	13.0
50-51	14.84	13.3
51-52	17.52	14.1
52-53	22.31	18.4
53-54	21.77	17.8
54-55	23.78	19.9
55-56	22.44	18.3
56-57	26.14	18.4
57-58*		
58-59	23.27	19.9
59-60	22.06	15.7
60-61	17.84	15.6
61-62	17.59	13.0
62-63	17.68	14.2
63-64	20.64	14.7
64-65	20.07	14.8
65-66	19.42	13.8
66-67	21.52	13.2
67-68	25.05	15.7
68-69	25.43	15.5
69-70	23.41	15.7
20 Year Average	20.91	15.75

* Data not available for intervening years.

Figure 10 — FIRST-YEAR ENGINEERING FALL ENROLMENT AS A PERCENTAGE OF STUDENTS ACHIEVING PASS — 50% OR BETTER — IN PHYSICS AND CHEMISTRY IN THE PREVIOUS SPRING DEPARTMENTAL EXAMINATIONS

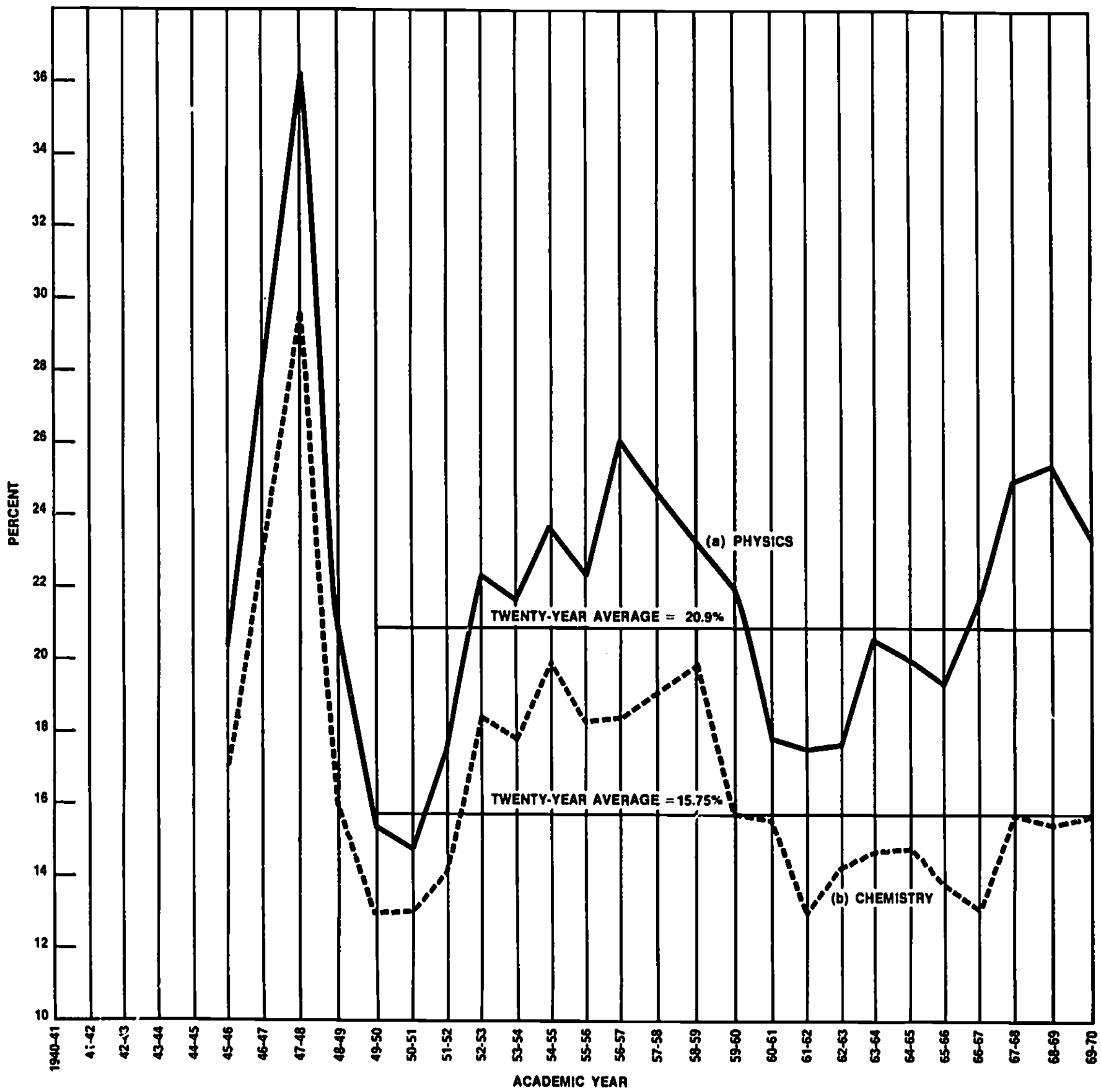


FIGURE 11

FIRST YEAR ENGINEERING ENROLMENTS AS A PERCENTAGE OF STUDENTS ENROLLED IN GRADE 13 IN THE PREVIOUS ACADEMIC YEAR, AND IN GRADE 12 - TWO YEARS PREVIOUSLY

Academic Year	(a) Percentage of Grade 13 - Previous Year	(b) Percentage of Grade 12 - Two Years revious
1945-46	9.25	
46-47	25.15	
47-48	15.66	
48-49	8.95	
49-50	7.14	3.96
50-51	6.87	3.69
51-52	7.65	4.00
52-53	10.46	5.25
53-54	9.96	4.89
54-55	11.17	5.50
55-56	10.48	5.31
56-57	10.99	5.47
57-58	12.46	6.00
58-59	10.93	5.48
59-60	8.73	4.66
60-61	7.46	3.91
61-62	6.96	3.70
62-63	6.84	3.80
63-64	7.18	4.04
64-65	7.12	4.00
65-66	6.81	4.23
66-67	6.85	4.25
67-68	7.81	4.06
68-69	7.65	3.95
69-70	6.66	3.56
70-71	6.31	3.34
71-72	6.14	3.23
72-73	6.23	3.24
73-74	6.16	3.19
74-75	6.04	3.10
75-76	5.98	3.04
76-77	5.93	2.99
77-78	5.84	2.95
78-79	5.77	2.91
79-80	5.68	2.57
80-81	5.67	2.86

Figure 11 — FIRST-YEAR ENGINEERING ENROLMENTS AS A PERCENTAGE OF STUDENTS ENROLLED IN GRADE 13 IN THE PREVIOUS ACADEMIC YEAR, AND IN GRADE 12 TWO YEARS PREVIOUSLY

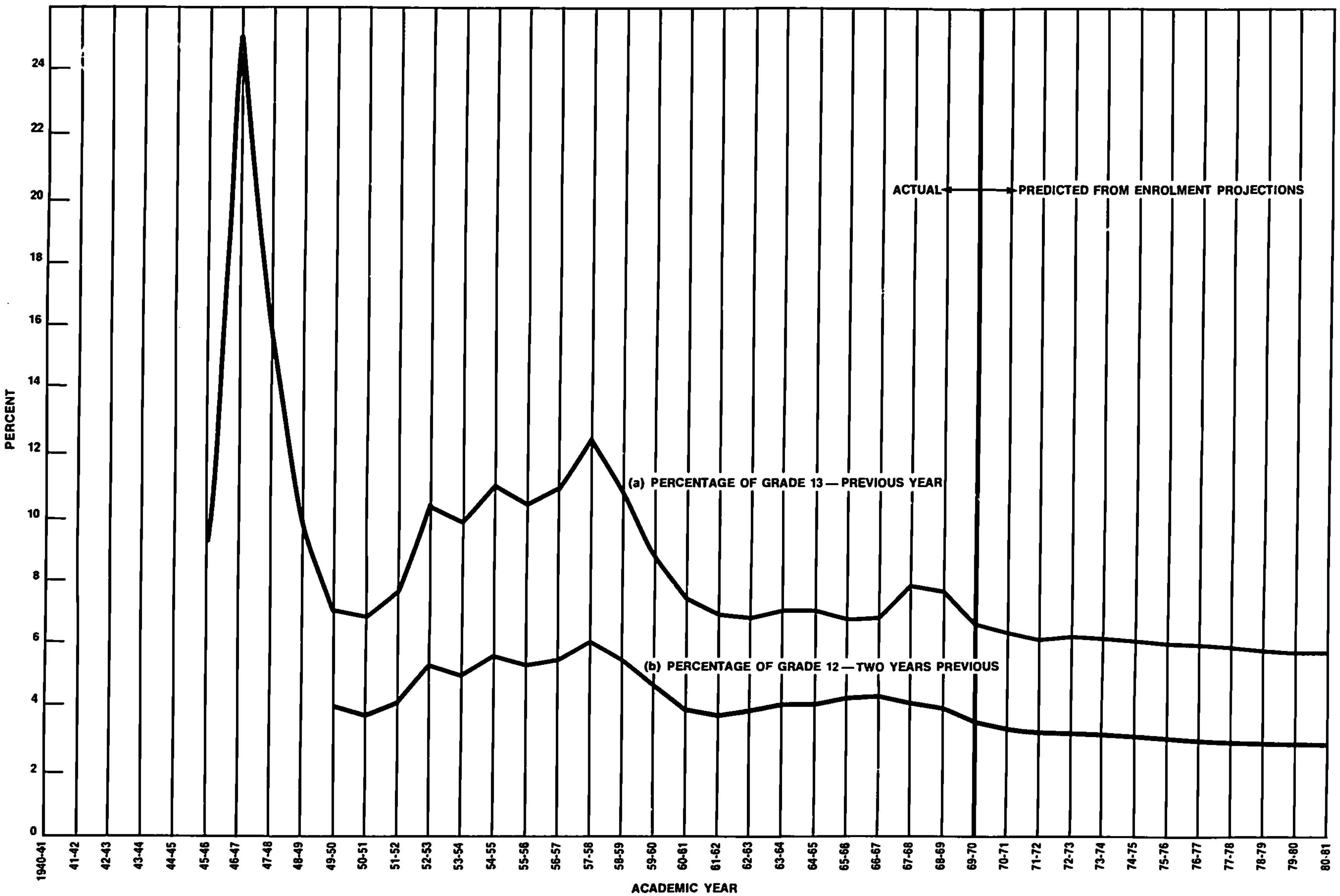


FIGURE 12

FIRST YEAR ENROLMENT RATIOS

Academic	(a) First Year Total University Enrolment as a Percentage of Students Enrolled in Grade 13 in the Previous Academic Year	(b) First Year Total University Enrolment as a Percentage of Students Enrolled in Grade 12 - Two Years Previous	(c) First Year Engineering Enrolment as a Percentage of First Year Total University Enrolment
1959-60	47.9	25.5	18.23
60-61	51.3	26.9	14.54
61-62	47.0	24.9	14.80
62-63	46.6	25.9	14.69
63-64	51.2	28.8	14.02
64-65	51.6	29.0	13.80
65-66	50.8	31.6	13.41
66-67	54.3	33.7	12.61
67-68	62.8	32.7	12.43
68-69	72.7	37.6	10.50
69-70	75.7	40.9	8.71
70-71	77.7	41.5	8.05
71-72	78.7	40.3	8.00
72-73	79.5	39.4	8.25
73-74	80.0	37.8	8.43
74-75	80.0	35.8	8.65
75-76	80.0	34.6	8.81
76-77	80.0	33.8	8.85

Figure 12 — FIRST-YEAR ENROLMENT RATIOS

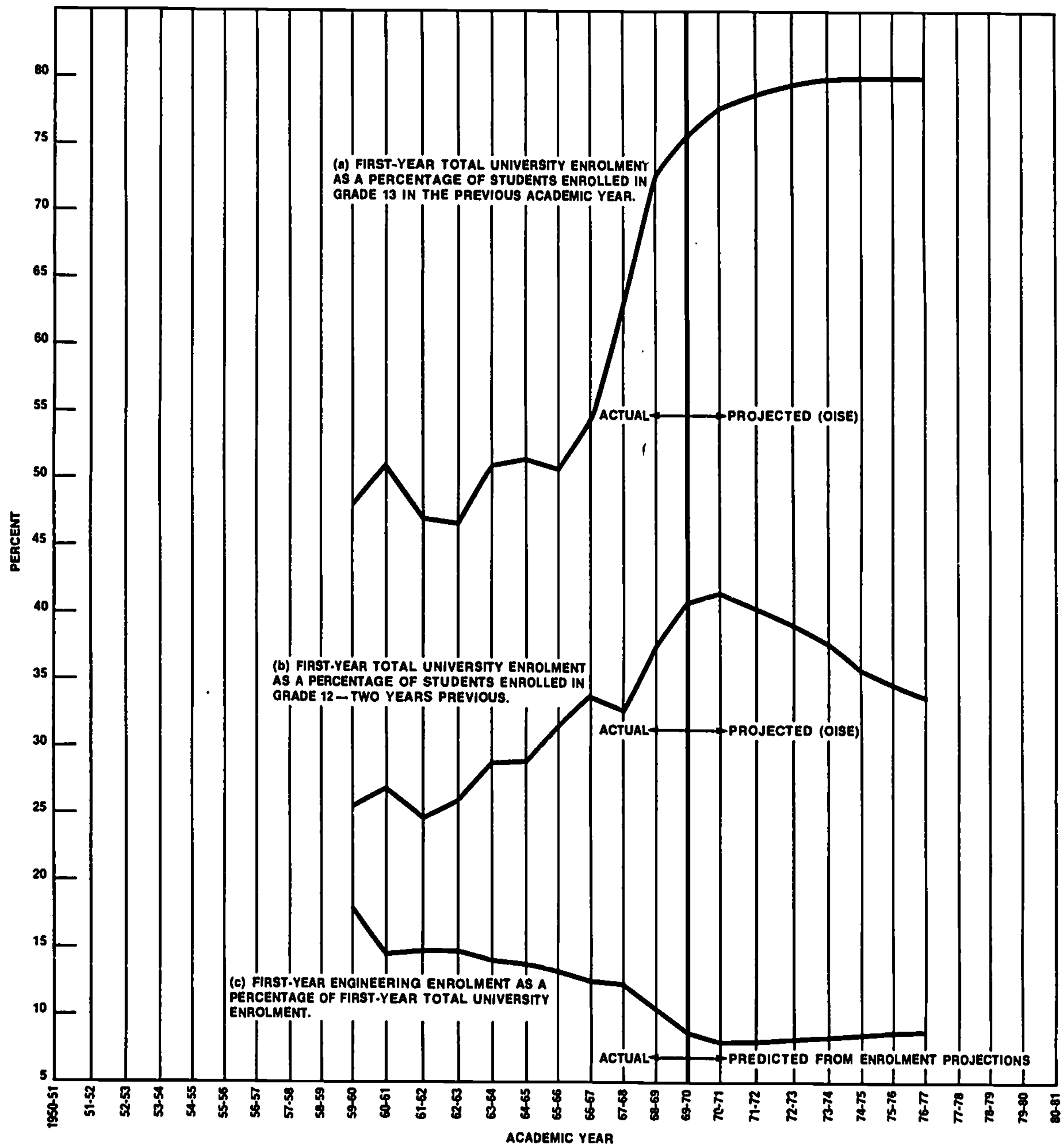
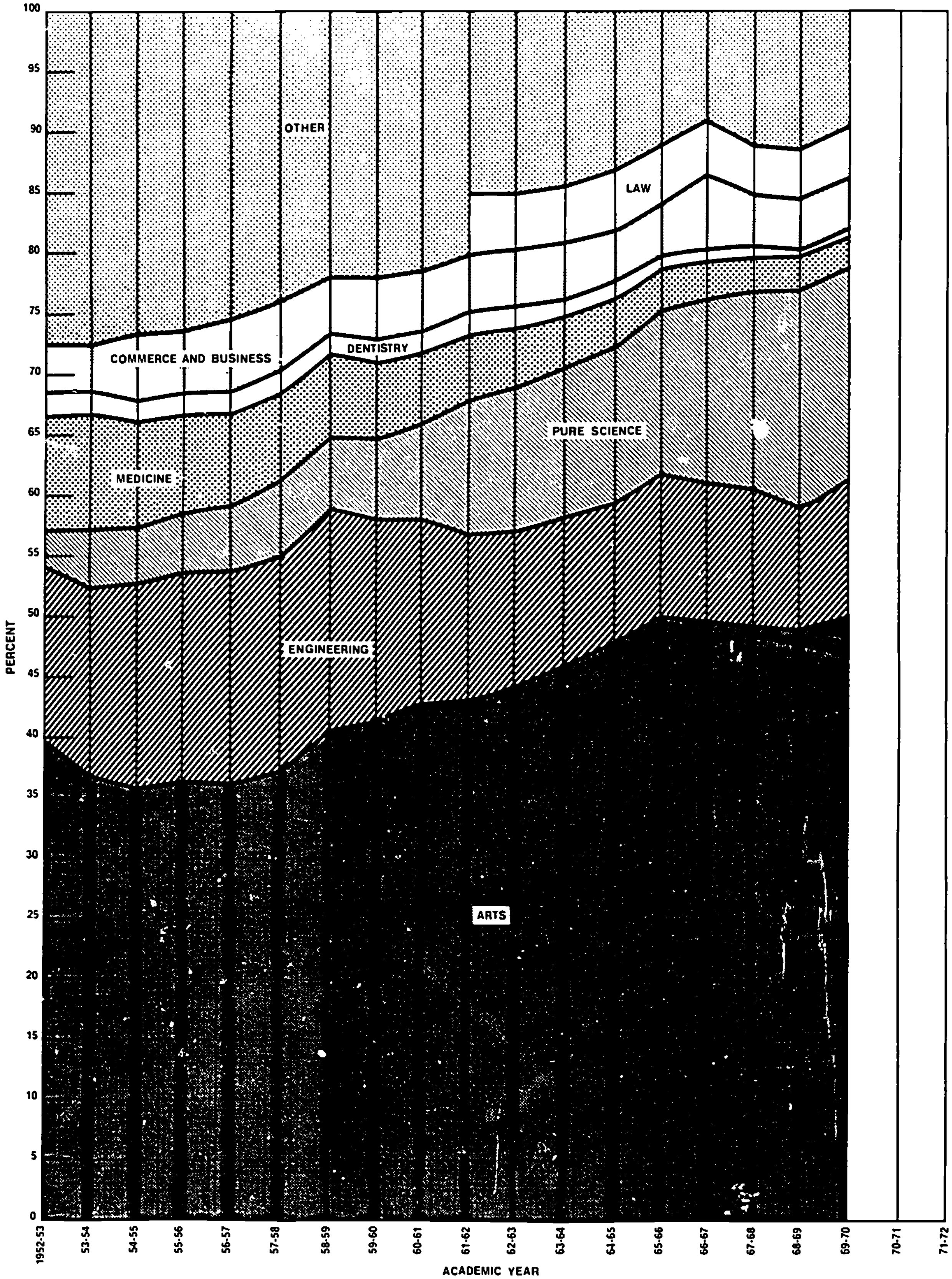


Figure 13 — ENROLMENT PERCENTAGES BY FACULTY



Source: Cicely Watson and Saeed Quazi "Ontario University and College Enrolment Projections to 1981/82", OISE Enrolment Projections No. 4, 1968.

FIGURE 14

TOTAL ENROLMENT RATIOS

Academic Year	(a) Total Engineering as a Percentage of Total University Enrolment	(b) Total Science as a Percentage of Total University Enrolment	(c) Total Engineering and Science as a Percentage of Total University Enrolment
1956-57	13.3	4.4	17.7
57-58	14.1	5.3	19.4
58-59	13.5	5.1	18.6
59-60	12.7	5.3	18.0
60-61	10.5	6.2	16.7
61-62	9.8	9.2	19.0
62-63	9.5	9.9	19.4
63-64	9.5	10.3	19.8
64-65	9.4	11.0	20.4
65-66	9.8	11.8	21.6
66-67	9.5	13.3	22.8
67-68	9.5	14.4	23.9
68-69	8.9	16.4	25.3
69-70	8.5	16.0	24.5
70-71	7.9	16.7	24.6
71-72	7.5	17.4	25.4
72-73	7.0	18.2	25.7
73-74	6.9	18.7	25.9
74-75	6.6	19.2	26.0
75-76	6.4	19.5	26.0
76-77	6.2	19.7	26.0
77-78	6.0	19.9	26.0
78-79	5.9	20.1	26.0
79-80	5.6	20.4	26.0
80-81	5.5	20.5	26.0

Figure 14 — TOTAL ENROLMENT RATIOS — ENGINEERING AND SCIENCE

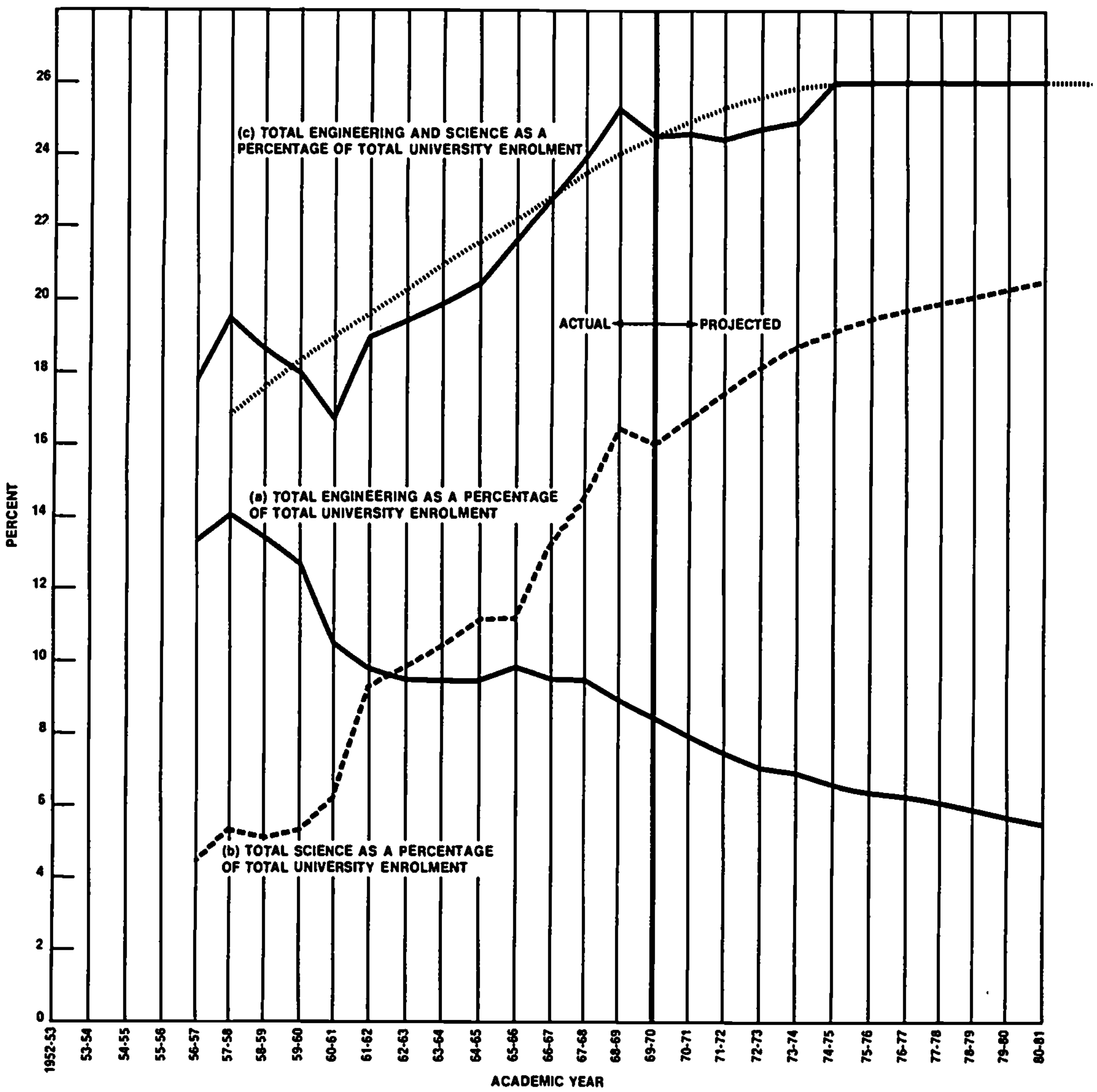


FIGURE 15

TOTAL ENGINEERING ENROLMENT RATIOS

Academic Year	(a) Total Engineering as a Percentage of Total University Enrolments (Main Projection Curve)	(b) Total Engineering as a Percentage of Total University Male Enrolments	(c) Total Engineering Enrolment as a Percentage of the Ontario 18-24 Male Age Population
1952-53			0.98
53-54			1.04
54-55			1.18
55-56			1.25
56-57	13.3	19.0	1.36
57-58	14.1	20.1	1.52
58-59	13.5	19.7	1.60
59-60	12.7	18.8	1.62
60-61	10.5	15.9	1.42
61-62	9.8	14.8	1.40
62-63	9.5	14.3	1.38
63-64	9.5	14.6	1.47
64-65	9.4	14.6	1.54
65-66	9.8	15.3	1.66
66-67	9.5	15.1	1.81
67-68	9.5	15.1	1.89
68-69	8.9	14.3	1.96
69-70	8.5	13.8	1.97
70-71	7.9	12.9	1.91
71-72	7.5	12.3	1.91
72-73	7.0	11.7	1.94
73-74	6.9	11.5	2.02
74-75	5.6	11.0	2.08
75-76	6.4	10.8	2.13
76-77	6.2	10.6	2.17
77-78	6.0	10.3	2.18
78-79	5.9	10.1	2.18
79-80	5.6	9.7	2.17
80-81	5.5	9.4	2.18

Figure 15 — TOTAL ENGINEERING ENROLMENT RATIOS

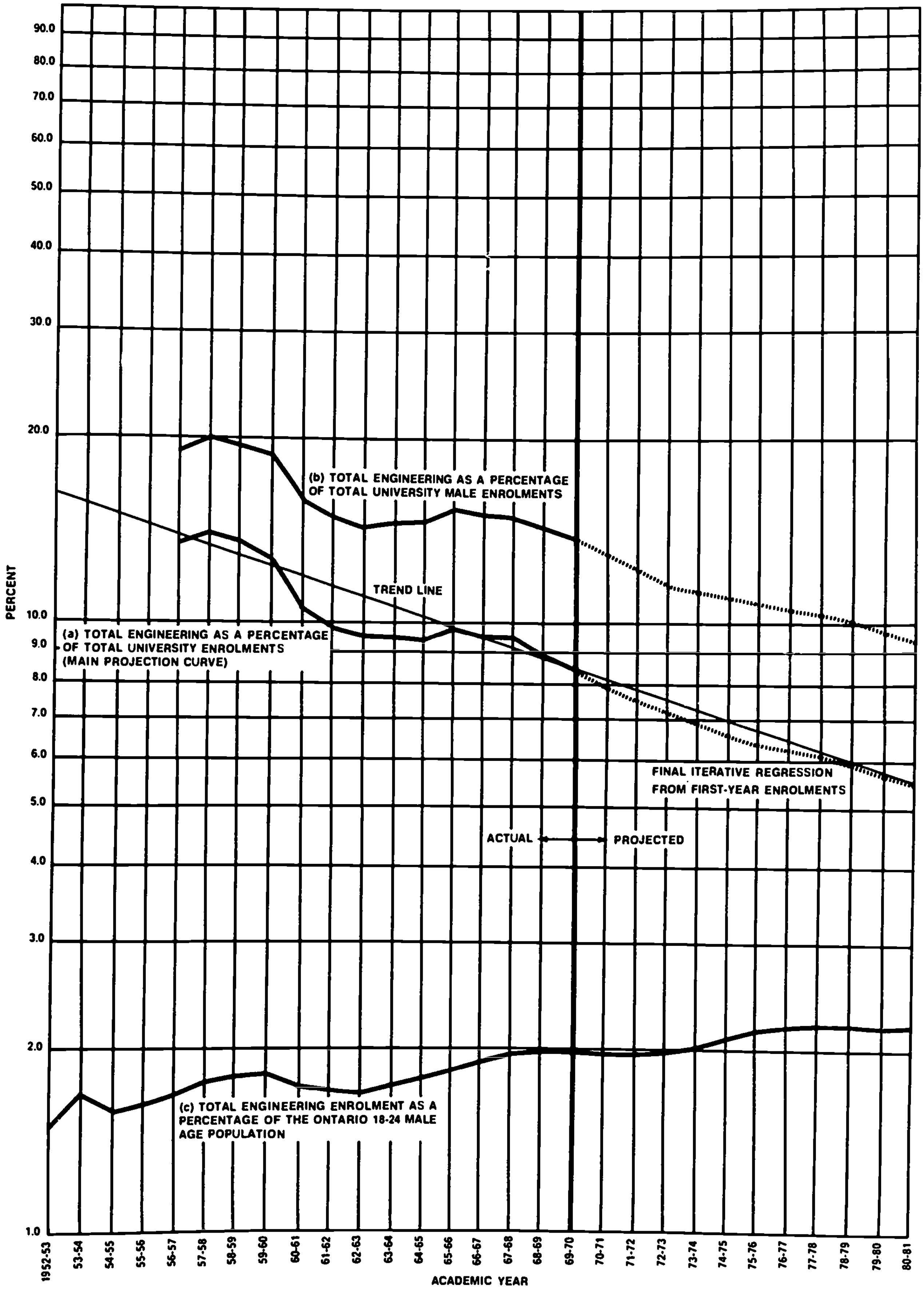


FIGURE 16

CANADIAN ECONOMIC INDICATORS

Academic Year	Employment (Percent)	Capital Investment (Millions of Dollars)	Gross National Product (Millions of 1957 Dollars)	Mean Previous Spring Starting Salaries - Engineering and Science - (Dollars)	Percent Change in Starting Salaries - Engineering and Science
1955-56	96.6	5,447	31,508	3,804	0.77
56-57	95.4	5,926	31,909	4,266	12.41
57-58	93.0	5,103	32,284	4,701	10.18
58-59	94.0	4,929	33,398	4,776	15.94
59-60	93.0	4,908	34,200	4,797	0.44
60-61	92.9	4,795	35,081	4,950	3.19
61-62	94.1	4,859	37,429	5,126	3.55
62-63	94.5	5,157	39,352	5,195	1.35
63-64	95.3	5,965	41,886	5,325	2.50
64-65	96.1	6,890	44,773	5,515	3.56
65-66	96.4	7,853	47,430	5,836	6.00
66-67	95.9	7,727	49,007	6,486	11.12
67-68	95.2			7,087	9.27
68-69	95.3			7,395	4.34
69-70	93.4			7,553	2.14

Figure 16 — CANADIAN ECONOMIC INDICATORS

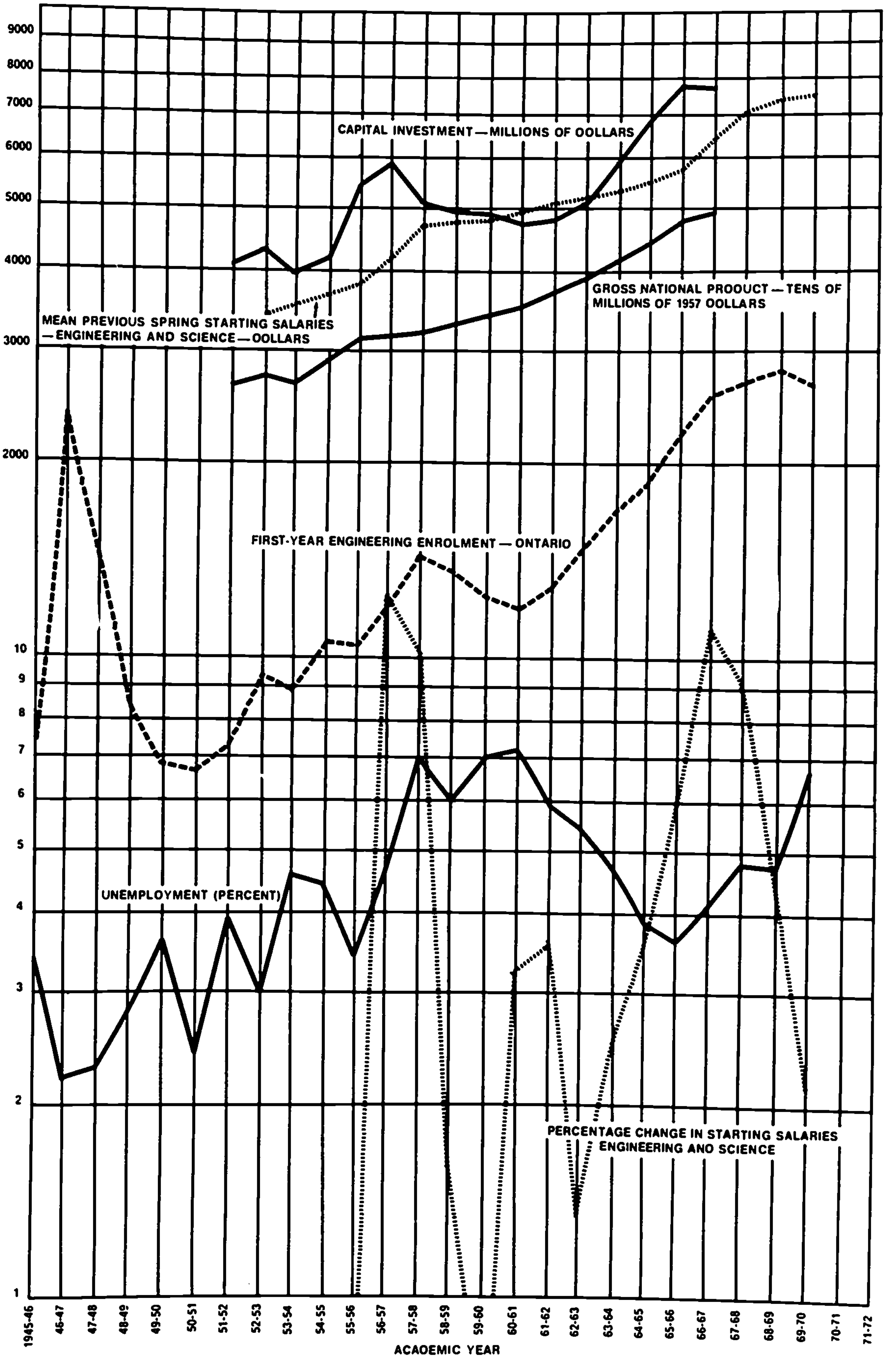
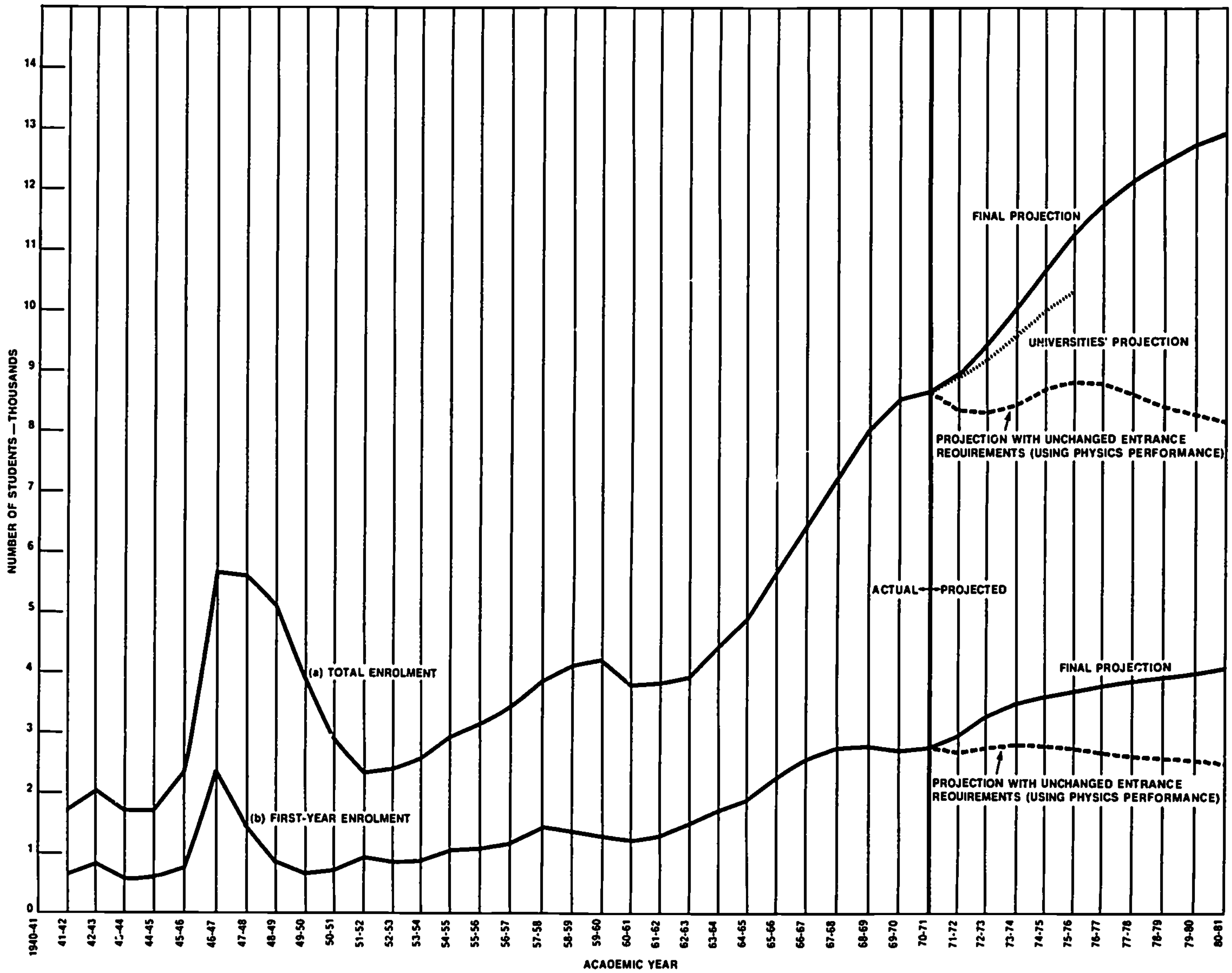


FIGURE 17

ENGINEERING UNDERGRADUATE ENROLMENTS

Academic Year	Total Enrolment - Final Projection	Total Enrolment - Universities' Projection	Total Enrolment - Projection with Unchanged Entrance Requirements (Using Physics Performance)	First Year Enrolment Final Projection	First Year Enrolment - Projection with Unchanged Entrance Requirements (Using Physics Performance)
1969-70	For actual enrolments to 1970, see Figure 1.				
70-71	8,620	8,540	8,620	2,750	2,750
71-72	8,448	8,899	8,326	2,970	2,660
72-73	9,401	9,167	8,300	3,290	2,740
73-74	10,061	9,563	8,452	3,500	2,800
74-75	10,672	9,957	8,738	3,610	2,780
75-76	11,247	10,272	8,855	3,695	2,730
76-77	11,763		8,790	3,780	2,640
77-78	12,166		8,603	3,855	2,610
78-79	12,466		8,408	3,915	2,580
79-80	12,712		8,276	3,970	2,530
80-81	12,950		8,154	4,040	2,460

Figure 17 — ENGINEERING UNDERGRADUATE ENROLMENTS



SOURCES FOR FIGURES 1-17

Figure 1a	1941-1959 Engineering Institute of Canada Journals, December issues. 1960-1970 Submissions from universities (Engineering Study).
Figure 1b	OISE unpublished tables.
Figure 1c	Cicely Watson and Saeed Quazi, Ontario University and College Enrolment Projections to 1981-1982, OISE Enrolment Projections No. 4, 1968.
Figure 2	Same as Figure 1a.
Figure 3a	Cicely Watson, Saeed Quazi and Sharon Burnham, Ontario Secondary School Enrolment Projections to 1981-82, OISE Enrolment Projections No. 2, (to 1963-64); Cicely Watson, Saeed Quazi, and Aribert Kleist, Ontario Secondary School Enrolment Projections to 1981-82, OISE, No. 5, 1969 (1964-65 on).
Figure 3b	Reports of the Ontario Minister of Education (to 1955-56); OISE No. 2 (1956-57 to 1962-63); OISE No. 5 (1963-64 on).
Figure 3c	OISE No. 5 - Summation from Tables 6, 8 and 11.
Figure 3d	Unpublished OISE Projections.
Figure 3c	Unpublished OISE figures (to 1962-63); OISE No. 4, (1963-64 on).
Figures 4, 5, 6, 7 and 9	Reports of the Minister of Education.
Figure 8	Dainton et al, Enquiry into the Flow of Candidates in Science and Technology into Higher Education, (London, England; Council for Scientific Policy, 1968).
Figures 10, 11 and 12	Derived from earlier figures.
Figure 13	OISE Projection No. 4. Tables A-1 to A-14.
Figure 14	Previous figures and Z. E. Zsigmond and C. J. Wenaas, Enrolment in Educational Institutions by Province, 1951-52 to 1980-81, Staff Study No. 25, Economic Council of Canada, January 1970.
Figure 15a and 15b	Zsigmond and Wenaas.
Figure 15c	OISE unpublished tables.
Figure 16	Economic Council of Canada - annual reports and Private Industrial Survey.
Figure 17	Figure 1 and projections; submissions from the universities.