Ph.D. Degree Program in Industrial Engineering

University of Rhode Island Faculty Senate

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TO: President Werner A. Baum  
FROM: Chairman of the Faculty Senate  

1. The Attached BILL, titled Ph.D. Degree Program in Industrial Engineering  

is forwarded for your consideration.  

2. The original and two copies for your use are included.  

3. This BILL was adopted by vote of the Faculty Senate on 71-11-11 (date).  

4. After considering this bill, will you please indicate your approval or disapproval. Return the original or forward it to the Board of Regents, completing the appropriate endorsement below.  

5. In accordance with Section 8, paragraph 2 of the Senate's By-Laws, this bill will become effective on 71-12-2 (date), three weeks after Senate approval, unless: (1) specific dates for implementation are written into the bill; (2) you return it disapproved; (3) you forward it to the Board of Trustees for their approval; or (4) the University Faculty petitions for a referendum. If the bill is forwarded to the Board of Trustees, it will not become effective until approved by the Board.  

ENDORSEMENT 1.  

TO: Chairman of the Faculty Senate  
FROM: President of the University  

1. Returned.  

2. Approved ___________. Disapproved ___________.  

3. (if approved) In my opinion, transmittal to the Board of Regents is not necessary.  

(/s/) President  

Form Revised 6/71
ALTERNATE ENDORSEMENT 1.

TO: Chairman of the Board of Regents.

FROM: The University President

1. Forwarded.
2. Approved.

_________________________ /s/ __________________________
(date) President

ENDORSEMENT 2.

TO: Chairman of the Faculty Senate

FROM: Chairman of the Board of Regents, via the University President.

1. Forwarded.

_________________________ /s/ __________________________
(date) __________________________
(Office) President

ENDORSEMENT 3.

TO: Chairman of the Faculty Senate

FROM: The University President

1. Forwarded from the Chairman of the Board of Regents.

_________________________ /s/ __________________________
(date) President

Original received and forwarded to the Secretary of the Senate and Registrar for filing in the Archives of the University.

_________________________ /s/ __________________________
(date) Chairman of the Faculty Senate
Faculty Senate Bill #71-72-5

Ph.D. Degree Program in Industrial Engineering

Consideration of Ph.D. degree program in Industrial Engineering. (Areas of emphasis to be offered are in applied operations research and materials processing metrology). Approved with the stipulation that students wishing to pursue the Materials Processing Option not be accepted until the vacancy in this area is filled and that adequate staff is available as determined by the Dean of the Graduate School, the Dean of the College of Engineering and the Vice President for Academic Affairs.
THE DEPARTMENT OF
INDUSTRIAL ENGINEERING
UNIVERSITY OF RHODE ISLAND

(ABBREVIATED)
PROPOSAL
FOR A GRADUATE PROGRAM LEADING TO THE
DEGREE OF DOCTOR OF PHILOSOPHY
IN
INDUSTRIAL ENGINEERING
SUMMARY

It is proposed that authorization be granted for the Department of Industrial Engineering to award the Doctor of Philosophy degree.

The Department of Industrial Engineering now has seven and one-half faculty positions; all but one of the faculty hold earned doctorates. Approximately thirty graduate level (or dual level) courses are now offered within the Department. The research budget has grown to a respectable level providing funded support for a variety of research projects. The principal support departments, (other engineering departments, Mathematics, Computer Science) have developed far beyond a minimal level of excellence necessary as a support unit for a doctoral program (all but two of the seven departments mentioned have doctoral programs). The computer facilities are excellent and a remote console has been placed in Gilbreth Hall. The library has sufficient volumes and journals to initiate a doctoral program in industrial engineering; the Department faculty has given careful attention to developing the holdings in areas of professional interest during the past three years in anticipation of this proposal.

Although there are several universities offering the doctoral degree in Industrial Engineering in the United States, in all of New England, the University of Massachusetts has the only doctoral program. The Department has had an increasing number of inquiries
from interested students about a doctoral program; principally, the interests have been in operations research and materials processing. Many of the universities with doctoral programs offer varying quality opportunities for study in operations research; few (about 4) offer high quality programs and research opportunities in materials processing. The major strengths the Department wishes to develop in the early years of a PhD program are in applied operations research and materials processing-metrology.

GENERAL REQUIREMENTS OF A DOCTORAL PROGRAM IN INDUSTRIAL ENGINEERING

The student entering the doctoral program in Industrial Engineering is assumed to have completed a masters degree. Normally, the masters degree will have been earned in Industrial Engineering. However, subject to faculty judgement for each individual case, a masters degree in other areas of engineering or in mathematics may be acceptable. When this occurs, it is anticipated that the student will usually be required to register for a set of deficiency courses, selected by his advisory committee, which will carry no program credit.

A student entering the proposed doctoral program with a masters degree will be expected to have academic credit in, or
equivalent knowledge of, the following:

At least three credits in linear algebra.
At least three credits in computer science.
At least six credits in operations research.
At least six credits in probability and statistics.

If, during the bachelors or masters plans of study or other educational experience, the student has not obtained academic credit in or equivalent knowledge of the above, he must satisfactorily complete a program, specified by his Graduate Study Committee, designed to meet these requirements. This may include formal courses, self-study assignments with proficiency examinations, or other methods, the selection of which will be at the discretion of the Committee. No program credit will be allowed for the above (i.e., the program credits for that portion of graduate study beyond the masters degree can not include the above.)

Each doctoral student must have had or must include in his plan of study a course in real analysis; he must include in his plan of study at least one other course in advanced mathematics to be taken in the Mathematics Department. In addition, at least six credits in probability, statistics or stochastic processes will be required beyond the six credits previously mentioned; the credits, if not taken prior to commencement of doctoral study, may be used for program credit. If the credits were obtained prior to commencement of doctoral study and were not used for requirements in another degree program, the student may request his Graduate Study Committee and the Graduate School to allow program credit.
The additional credits necessary to complete at least the minimum requirements (beyond a masters degree) of twenty four credits of course work plus eighteen credits for dissertation research will be organized into a meaningful plan of study by the student and his advisory committee.

The student must fulfill research tools requirements as specified by the Graduate Study Committee. These requirements may include one of the following or a combination thereof:

a) Two foreign languages. The selection of the languages and the testing procedure to determine proficiency will be determined by the Committee to meet individual needs.

b) Demonstrated proficiency in one or more areas. These areas will generally be technical or mathematical but may not be for some individuals. The manner in which proficiency is to be demonstrated will be determined by the Committee.

The research tools requirements will be assigned by the Committee to supplement the plan of study and meet the student's anticipated research or career needs.

The student must meet all University requirements for doctoral study, as specified in the Graduate School Bulletin, and the Graduate Student Manual, under the section "Doctor of Philosophy Degree Requirements".
THE NEED FOR A DOCTORAL PROGRAM IN INDUSTRIAL ENGINEERING

The need for a doctoral program in Industrial Engineering could be justified in terms of the educational and research service for southern New England. But in all of New England and Eastern New York State there is only one doctoral program presently in existence, located at the University of Massachusetts, Amherst, with an enrollment of twelve doctoral students in 1969-70. No others appear to be planned for the immediate future. Since the emphasis at the University of Massachusetts is sufficiently different from the objectives at the University of Rhode Island, it appears quite reasonable to conclude that the most immediate area to be served is all of New England. It is fully anticipated that some doctoral students will come here from various parts of the United States and several foreign countries but the principal consideration will be for local needs of Rhode Island and southern New England.

Programs of study leading to a Masters Degree are offered at two other New England institutions: University of Massachusetts and Northeastern University. They have enrollments in their Masters Programs of eighteen and seven hundred and sixty-nine, respectively. (Over ninety per cent of the Northeastern enrollment are part-time students.)

If the need for an industrial engineering doctoral program can be assessed in terms of the inquiries received, it can be concluded
that a need does exist. Approximately thirty inquiries have been received during the past two years from prospective students; the principal interests have been in materials processing—metrology and operations research.

There are approximately thirty-five universities offering doctoral programs in Industrial Engineering in the United States and Canada. They are of various size ranging from the large effort at University of California, Berkeley, (46 doctoral students) to a modest program such as Iowa State (5 doctoral students). Average departmental size is 15 doctoral students but this has a wide variation. The University of Oklahoma and the University of Massachusetts initiated doctoral programs with five and six faculty members, respectively; they have now grown to eight and ten faculty members since the inception of the programs in 1966, which, clearly, are not dramatic increases in faculty size and is probably little more than the growth rate that might have otherwise occurred. Both programs are presently of commendable quality. Judging from the statistics of other departments with doctoral programs, it would appear that a quality program can be sustained with a faculty as small as seven to ten. For a department with seven and one-half positions (URI) and objectives for quality development in a limited number of areas of doctoral work, a new doctoral program does not place large and imposing demands for faculty. Neither would the demand for laboratory space or equipment abruptly or significantly exceed the rate of support which has been sought during the past three years.
The academic emphases in other industrial engineering departments, as may be expected, vary considerably. Most departments have a reasonable depth in operations research which is now a foundation area of industrial engineering; some departments have their greatest depth and emphasis in operations research (such as Northwestern University). The principal strength of a department might be in other areas such as human factors, bio-engineering, production engineering, bio-mechanics, or materials processing. Many departments are highly applications oriented; for example, one department is significantly involved in tree harvesting and lumber products which is reflected not only in their research but in their courses as well.

The Department of Industrial Engineering at the University of Rhode Island wishes to offer doctoral programs where the principal areas of specialty in the initial years are in operations research and materials processing—metrology. Operations research, in its most general sense, is concerned with mathematical modeling of physical systems and includes solution techniques for attaining a desired set of objectives. For operations research, mathematics (all areas of mathematics including probability and statistics) and computer science are the foundation elements; in addition, a thorough knowledge of the physical system under consideration is required before modeling can be accomplished and solution procedures designed. Materials processing, as an area of knowledge, is concerned with the dynamics of a materials processing system, the material science of the tool—workpiece interaction, and all
aspects of the machine components of the system. Metrology is the science of measurement (linear, contour or geometrical, comparative, surface, etc.). Optics, light waves, electromechanical devices, fluid devices, laser technology and a host of other techniques are used. Total design of the measurement system is the principal objective; this would include determining the necessary measurements, designing a procedure for obtaining these measurements, and selecting the proper instrumentation for optimal results, carefully considering the processing method, quality objectives, and functional use of the process or product under consideration. As indicated earlier, operations research has become a foundation discipline in industrial engineering as well as a specialty. A wide variety of plans of study in operations research with varying degrees of applied orientation can be developed. The utilization of the discipline has become extremely broad, currently in use to some degree in all classes of commercial enterprises, in many non-profit organizations, and in several areas of research. The potential is far-reaching. There is also a considerable amount of research in operations research underway at several universities.

The area of specialty that is in very short supply is materials processing-metrology. Only a few quality programs exist in the United States. Consequently, the professional manpower in this area is also in very short supply. But the need for new technology and knowledgeable manpower has been rapidly growing; the proliferation of new materials for the space and oceanographic
sciences has created a situation where conventional processing and metrology technology is no longer adequate. (In the spring of 1970, the National Science Foundation began to focus a great deal of attention on the processing of the new materials.)

As indicated earlier, it is believed that in the initial efforts the two principal thrusts in a doctoral program should be in operations research and materials processing-metrology. With the large number of support courses that are available, a variety of plans of study can be developed. Statistics and probability will inevitably form an important minor for nearly all plans of study. Computer science and mathematics will be vital foundation areas. In addition to the fact that the manpower resources are available in the Department and in service departments to offer study opportunities as described, it is believed that the more immediate needs of the State and the region can be effectively served by applied programs of instruction and research in the areas discussed. New courses and new programs can be offered as the resources become available and the need becomes evident. However, it should again be emphasized that a variety of plans of study are feasible within the two areas indicated using existing courses at the University.

RESEARCH FUNDING

Research funding since 1967 includes the following:
<table>
<thead>
<tr>
<th>Organization</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memorial Hospital</td>
<td>$10,000</td>
</tr>
<tr>
<td>Westerly Hospital</td>
<td>12,000</td>
</tr>
<tr>
<td>Rhode Island Hospital</td>
<td>52,000</td>
</tr>
<tr>
<td>Naval Air System Command</td>
<td>85,000</td>
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<tr>
<td>National Science Foundation</td>
<td>18,000</td>
</tr>
<tr>
<td>Society of Manufacturing Engineers</td>
<td>5,000</td>
</tr>
<tr>
<td>Materials grants from industrial companies</td>
<td>4,000</td>
</tr>
<tr>
<td>Public Health Service</td>
<td>35,000</td>
</tr>
<tr>
<td>Rhode Island Health Services Research, Inc.</td>
<td>25,000</td>
</tr>
</tbody>
</table>
GENERAL DISCUSSION

A doctoral program in Industrial Engineering would establish, in greater breadth and depth, levels of activities in operations research and materials processing. There would be more opportunities to provide, for the State, short courses, consulting and other special service in these areas. In addition, research results will be available; this benefit can be of some consequence as the base of research is always expanded in doctoral program.

The two areas of concentration planned by the Department, materials processing and operations research, have significant potential value for the State. There are a large number of metal product firms, hence, materials processing can offer obvious benefits. (There have been a number of instances of association already. These include Brown Diamond Company, Grinnell, Kaiser Aluminum, International Machine Tool Company and Bulova Watch Company.) Most of the organizations in Rhode Island are relatively small. The use of operations research in small firms, particularly in Rhode Island, has been quite limited, yet the potential benefits are very many. With short courses, consulting, and research results along with the regular program of campus education, it appears reasonable to expect that a considerable amount of this knowledge can permeate the organization of industry in the State for the benefit of everyone. In addition, the hospitals have only recently begun to recognize the advantages of systems design and operations research. The program of
operations research, broad based and intense, could offer them many benefits. The Department has already had affiliations with three hospitals in the State in which the hospitals funded some studies; these have included research concerned with the new Multi-Phasic Screening Center at Rhode Island Hospital plus a multitude of studies of hospital operational problems.

A doctoral program will nearly always expand the base of funded research for an academic department. For the year 1969-70 at the University of Rhode Island, the average annual research expenditures per faculty member for engineering departments with doctoral programs was $15,600; for engineering departments not offering the PhD, it was $11,300. Funded research yields a substantial income for the University from released time and overhead accounts plus capital equipment acquisitions.

The Department envisions a doctoral program with an enrollment limited to five to ten students during the first few years. Any expansion of that enrollment would be done only with great care and consideration. The doctoral program would be coupled with an undergraduate enrollment of 100-120, and a masters enrollment of 20-35. (In the initial years, it is anticipated that the masters enrollment will be curtailed, perhaps as low as twenty, in order to be able to initiate a doctoral program without requiring large, immediate resource inputs into the Department).
The Department of Industrial Engineering has developed the strength, capability, and courses necessary to initiate a doctoral program. Hence, no large increase in budget would be created solely by the abrupt existence of a new doctoral program. Manpower additions will be necessary but the acquisition rate should not exceed that of normal growth for the on-going programs which do not include doctoral study. (This is due to the foundation that has been developed in the three years prior to the submission of this proposal. No quick, massive build-ups are necessary in any area.) A large size is not an objective of this Department; high quality instruction and research in a limited number of areas is the principal objective. It should be emphasized that the initiation of a doctoral program in Industrial Engineering would not create increases in the operating or capital budgets over and above those needs which already exist for the on-going programs.
GRADUATE FACULTY OF INDUSTRIAL ENGINEERING

Charles F. James, Jr., Professor and Chairman. BSME, 1958; MSIE, 1960; PhD, 1963, Purdue University. Areas of interest: Applied statistics, compensation systems, health service systems.

D. Edward Nichols, Professor. BSIE, 1951; MSIE, 1952, Syracuse University. PhD, 1958, Purdue University. Areas of interest: Reliability, quality control, health service systems.

Stanley Rubinsky, Associate Professor. BME, 1938, Polytechnic Institute of Brooklyn. MME, 1950, University of Delaware. Advanced study, 1969-70, Northeastern University. Areas of interest: Human factors, engineering economy, safety systems studies.


Michael H. Branson, Assistant Professor. BS (Math), 1963, St. Procopius College. MA (Math), 1965; PhD, 1969, Arizona State University. Areas of interest: Operations research, stochastic processes, health service systems.

Edward R. Lawson, Assistant Professor. BSME, 1963, University of Rhode Island. MS, 1966, Rensselaer Polytechnic Institute. PhD, 1971, Purdue University. Areas of interest: Materials processing, operations research, control systems.

There is one vacant position.
HYPOTHETICAL PLAN OF STUDY

Operations Research

Operations Research - 15 credits

IDE 500  Network Applications in Industrial Engineering
IDE 555  Engineering Applications of Mathematical Programming I
IDE 556  Engineering Applications of Mathematical Programming II
IDE 565  Theory of Scheduling
IDE 657  Geometric and Dynamic Programming

Statistics and Probability - 9 credits

Math 550  Advanced Probability
IDE 634  Design and Analysis of Industrial Experiments
IDE 635  Response Surfaces and Evolutionary Operations

Mathematics - 9 credits

Math 535  Measure Theory and Integration
Math 629  Functional Analysis I
Math 635  Selected Topics in Real Analysis I

Dissertation: 18 credits

Total: 51 credits
HYPOTHETICAL PLAN OF STUDY

Materials Processing

**Materials Processing** - 12 credits

- IDE 541 Materials Processing and Metrology II
- IDE 641 (ChE 637) Molecular Aspects of Materials Processing
- IDE 642 Advanced Topics in the Processing of Materials I
- IDE 691 Advanced Special Problems in Industrial Engineering

**Materials Engineering** - 3 credits

- ChE 537 Advanced Materials Engineering

**Operations Research** - 6 credits

- IDE 550 Advanced Topics in Probabilistic Operations Research I
- IDE 610 Topics in Applied Queuing Theory

**Applied Statistics** - 9 credits

- IDE 525 (CS 525) Simulation
- Exp. Stat. 511 Linear Statistical Models
- Exp. Stat. 520 Fundamentals of Sampling and Application

**Mathematics** - 6 credits

- Math 572 Numerical Analysis
- Math 641 Partial Differential Equations I

Dissertation: 18 credits

Total: 54 credits