CoA Note No. 39

THE COLLEGE OF AERONAUTICS

CRANFIELD

AMERICAN TEACHING AND PRACTICE OF INDUSTRIAL ENGINEERING AND MANAGEMENT

by

J. CHERRY

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American Teaching and Practice of Industrial Engineering and Management

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SUMMARY

In June 1954 a small mission, comprising T.B.Worth, M.I.Mech.E., A.M.I.E.E., M.I.Prod.E., F.R.S.A., Principal Senior Lecturer in Production Engineering and Assistant Head of the Department of Mechanical and Production Engineering at Birmingham College of Technology, K.J.Shone, M.A. (Cantab), A.M.I.Mech.E., M.I.Mar.E., M.E.I.C., Head of Department of Industrial Administration, Royal Technical College, Glasgow, and the author, visited the United States of America to "observe and gain experience of American methods of training in Industrial Engineering and Management both in universities and industrial plants". Subsequently, in September, D.M.Williams, Ph.D., B.Sc., (H.M.I.) joined the mission, which returned in November 1954.

Each member investigated different aspects and separate reports are being presented. This report deals mainly with education in Industrial Engineering. Other sections, dealing with education in Management, Industrial Engineering and Management in Industry, Research and Consultancy will be presented subsequently by the author.

Education in Industrial Engineering in the U.S.A. laid emphasis on the need for sound education in the basic and engineering sciences prior to the study of Industrial Engineering subjects. Considerable attention was paid to the economic aspects of industry and subjects such as Engineering Economic Analysis were prominent. Awareness of the impact of new developments in the industrial engineering field was also evident and curricula were being revised to introduce subjects such as Electronic Theory into the electrical programme, and the application of Operations Research techniques to the mathematics programme.

The value of formal education in Industrial Engineering was acknowledged by most industrialists, who were absorbing I.E. graduates at a rate exceeding 1500 per annum. In 1954 there were approximately 8,000 students enrolled in I.E. courses. A comparison of equivalent courses in Great Britain showed that less than 50 students were enrolled. The comparison also revealed the inadequacy of the Higher National Certificate courses in Production Engineering, and a strong plea is made for more facilities for students to take Higher National Diploma courses in Production Engineering.

CORRIGENDUM

Page 37 should read

'R. M. Barnes, Ph.D., Professor of Production Management, University of California, Los Angeles.'

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Preface

This visit (Technical Assistance Project T.A.57-293) was made under the auspices of:-

The Foreign Operations Administration, Washington D.C.

The Office of Education, U.S. Department of Health, Education and Welfare, Washington D.C.

The Ministry of Education, London, England,

and with the cooperation of the Board of Governors of the College of Aeronautics, Cranfield, England.

Introduction

The purpose of this visit to the U.S.A. was to study in greater depth than hitherto, American teaching and practice in the fields of Industrial Engineering and Management. Hence a small group of independent observers was given the terms of reference "To observe and gain experience of American methods of training in industrial engineering and management, both in universities and industrial plants".

Under these terms of reference a comprehensive study was made of industry's requirements in the fields of industrial engineering and management and how the universities and industry combine to meet those requirements.

To enable the broadest experience to be gained, the members of the group operated independently where advantageous. Also, since concentration has been mainly in the subjects of our major interests, each member is presenting a separate report. Dr. D. M. Williams has included a study of Higher Education preparatory to a university course; K. J. Stone has placed emphasis on the management aspects, and T. B. Worth and the author have accentuated Industrial Engineering.

Outline of the Survey

To provide as comprehensive experience as possible without sacrificing depth of study, the programme was arranged to include attendance at conferences on Industrial Engineering and Management, visits to universities and technical institutions, and participation in courses on Industrial Engineering and Management.

A representative cross-section of American industrial and educational establishments was visited, embracing eight states, eighteen educational institutions, eighteen industrial plants, one manufacturers' association and one firm of industrial consultants.

Details of the programme are shown in Appendix 1.

2. Summary of Industrial Engineering

Definition:

So rapid has been the expansion of this subject that no general agreement could be found among the American educators or industrialists in defining the functions and boundaries of Industrial Engineering.

The concepts of Industrial Engineering have evolved from the technical or mechanistic interpretation in Taylor's era, through the human and managerial phase and are now further expanding to embrace a much higher degree of mathematics in the solution of industrial problems.

Not all educational establishments agree on which facet emphasis should be placed. Indeed, not all agree on the term Industrial Engineering, hence closely related courses are found under other titles, as:- "Management Engineering", "Administration Engineering" and "Business and Engineering Administration".

For the purpose of this report, for the sake of brevity and without prejudice to the omitted titles, all related courses as previously mentioned will be included under the heading "Industrial Engineering".

It appears that the problem of compressing the extensive range of subject material into an undergraduate course has not yet been solved, thus creating the tendency to emphasise certain subjects to the exclusion of others. Undoubtedly each group makes valuable contribution to the fulfilment of the range of industrial requirements, hence the wisdom of avoidance of rigidity in curricula.

General agreement existed, however, that the foundations of Industrial Engineering must be laid on a sound knowledge of science, engineering and mathematics; also that the social/humanistic studies should form an integral part of the curriculum.

Engineering education in general is placing more weight on teaching fundamentals as recommended in the "Preliminary Report of the Committee on the Evaluation of Engineering Education", October 1953, which advised increased emphasis on mathematics, physical science and the following nine engineering sciences:- statics, dynamics, strength of materials, fluid flow, heat flow, thermodynamics, electrical currents, fields and electronics, engineering materials and physical metallurgy. Since most Industrial Engineering colleges have a common course for the first year with other engineering departments, the overall aims are in harmony.

Generally speaking, among educators, emphasis veered to the design functions of Industrial Engineering , and this is exemplified in the following definition of Industrial Engineering, which was widely supported:- "Industrial Engineering is the design of manufacturing units for maximum efficiency through the creative application of scientific principles and the prediction of their behaviour with respect to performance, costs and safety under specified conditions".

Investigation of the functions of an Industrial Engineering department revealed two lines of thought; one in which the function was principally administrative and in the other, mainly of a design nature, without responsibility for day-to-day administration.

FIGURE 1

EXAMPLE OF ADMINISTRATIVE TYPE OF INDUSTRIAL ENGINEERING FUNCTION

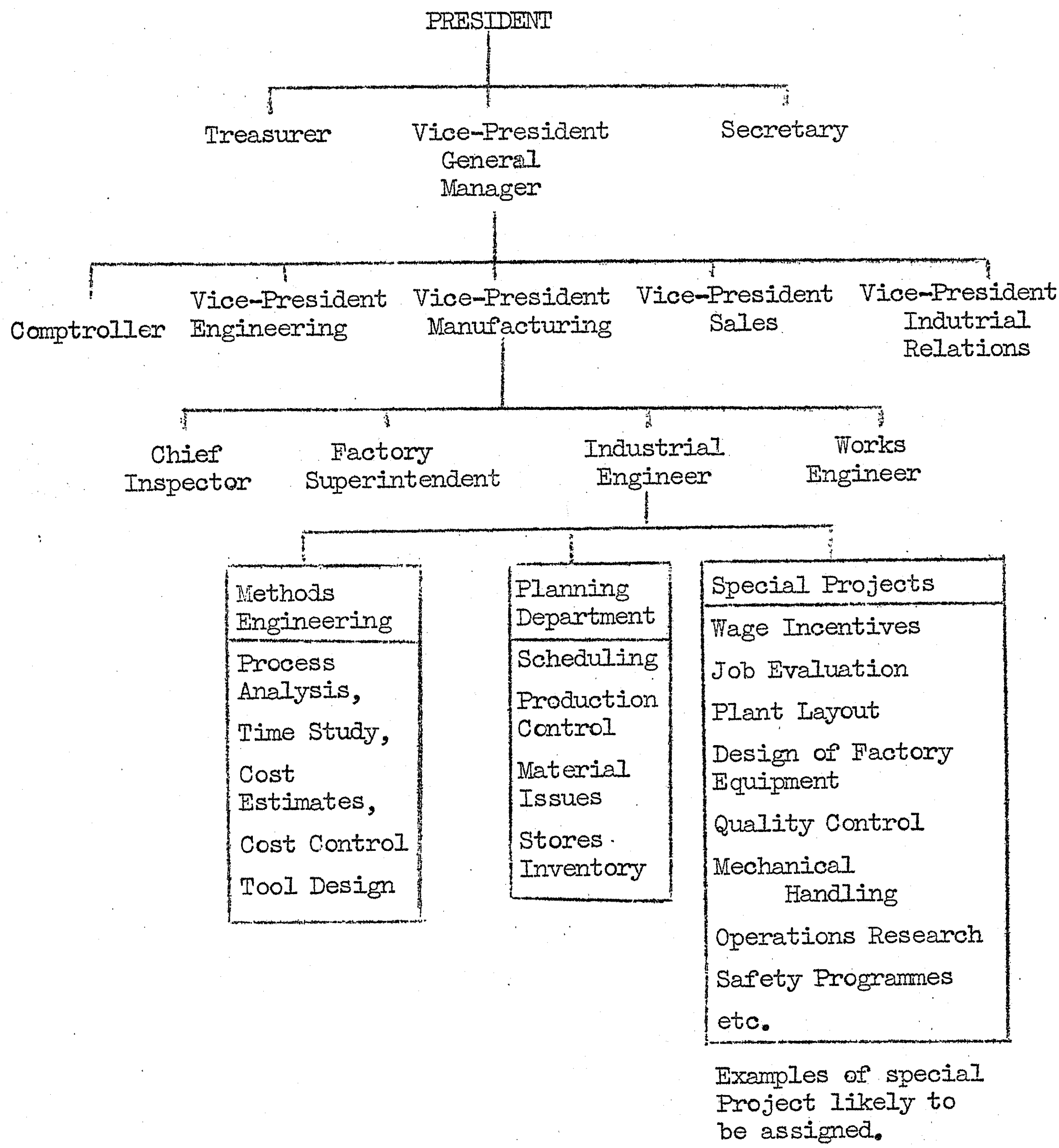
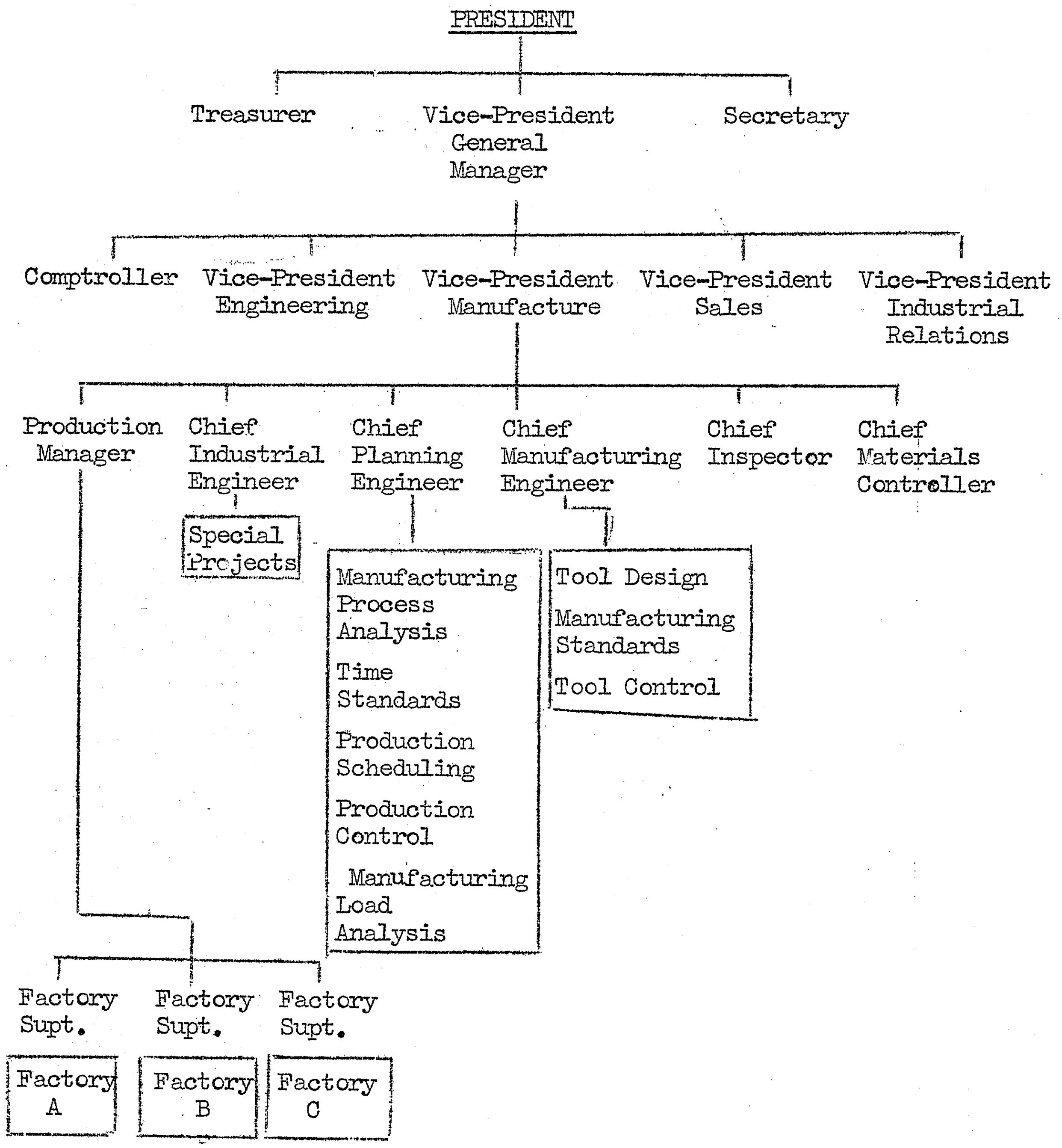


FIGURE 2

EXAMPLE OF NON-ADMINISTRATIVE TYPE OF INDUSTRIAL ENGINEERING FUNCTION



These approaches are not conflicting but are more evolutionary; the separation of an Industrial Engineering department as a design and advisory function existing more commonly in the larger organisations, where the responsibilities for administration were very heavy, (making a division of labour desirable) or where more than one plant was involved, thus centralising the Industrial Engineering Department. In the latter cases the Industrial Engineering Department undertook special investigations when requested by the Production Manager or by higher management.

Figs 1 and 2 show the general organisation structure for these two approaches.

Although the nature of the approaches is different, nevertheless there is unanimous agreement that the functions enumerated in figure 1 are Industrial Engineering functions. Indeed many educators would extend these functions to include Labour Relations and Personnel Policies etc., and whilst agreeing that a knowledge of human relations is most desirable for an Industrial Engineer, it was not found in practice that these functions were undertaken by the Industrial Engineering Department. On the contrary, it was experienced that very powerful Industrial Relations departments operated in all the plants visited and such matters were their prerogative.

Comparison of American undergraduate courses in Industrial Engineering, and U.K. Higher National Certificate courses in Production Engineering, show the latter do not justify comparison. Only by the addition of a course in Industrial Administration is the American course approached in material content. On the other hand the Higher National Diploma (sandwich) course in Production Engineering compares favourably with the American courses. So also does the type of university course in Production Engineering as given by Manchester University. However, the number of students attending the Diploma course in the United Kingdom in 1953/4 was only 40, and in the University Degree course only 4 students are enrolled in 1955/6 - quite an insignificant total. A few post-graduate courses in Production Engineering or equivalent are offered, and such a course superimposed on an engineering Degree or Higher National course would enable favourable comparison to be made with the American courses in Industrial Engineering. There are 52 students enrolled in this type of course at present.

2. 2. Educational Approaches

As previously stated, there is a concensus of opinion in American educational circles that Industrial Engineering is primarily "engineering" and must be founded on mathematics and the basic sciences of physics and chemistry. One renowned institution whose emphasis is towards administration clearly expresses this viewpoint, as illustrated in the following extract from their catalogue:- "Not only is it apparent that the successful management of industrial enterprises demands ability to understand and cope with problems of ever increasing complexity, but it is believed that fundamental training in science and engineering inculcates habits of precise thinking which are of great value in the study of all aspects of business administration."

Concurrence with this viewpoint is revealed in the examination of various college curricula in which, in addition to mathematics, physics and chemistry, the following subjects were common:- statics, dynamics, strength of materials, fluid flow, heat flow, thermodynamics, electricity, engineering materials and physical metallurgy. In most cases the first year was common for all engineering students.

Other subjects common to most curricula were:- foundry practive, machine shop practice, machine design, motion and time study, economics, personnel administration, cost accounting, production planning and control and humanistic - social subjects.

Completion of the course is made by a selection of technical, administrative or mathematical subjects as outlined:-

(a) Technical

Manufacturing processes, process planning, tool design, plant layout, materials handing, job evaluation, design for production, safety engineering, welding engineering.

(b) Administrative

Industrial management, finance, marketing, industrial relations, industrial law.

(c) Mathematical

Higher mathematics for engineers, quality control, statistics, advanced statistics for engineers.

It was on the emphasis to be placed on each of these three latter divisions that divergence of viewpoint was found. Some colleges emphasised one or other of these approaches, whilst others offered most of the variants as elective subjects at the option of the student.

Incidentally, it was very apparent that most colleges were making strenuous efforts to raise the intellectual level of education in Industrial Engineering to at least the equivalent of other engineering courses. Awareness of the impact of new developments in the industrial engineering field was also evident, and curricula were being revised to introduce subjects such as electronic theory into the electrical programme, and the application of operations research techniques to the mathematics programme.

There were 84 institutions offering courses in Industrial Engineering, and these took a variety of forms, some of which are outlined:-

4-year full-time course leading to a bachelor's degree
5-year full-time course leading to a bachelor's degree
5-year co-operative course leading to a bachelor's degree
2-year post-graduate course leading to a master's degree
(for graduate engineers other than I.E.)
1-year post-graduate course leading to a master's degree
(for I.E. graduates)
4-year post-graduate evening course leading to a master's degree
2-year post-graduate co-operative course leading to master's degree
3-year post-graduate course leading to a Doctor's degree
4-year post-graduate co-operative course leading to a Doctor's degree
Part-time teaching and part-time study courses leading to Master's and Doctor's degrees.

Such a spread of courses caters for most classes of students.

Although uniformity of curricula is not demanded, a high standard of teaching in the requisite subjects is required before the course is 'accredited' by the Engineers' Council for Professional Development. (See 2.3)

There are thirty such courses in Industrial Engineering accredited by the E.C.P.D.; in addition there are fourteen institutions having Industrial Engineering options as part of other accredited curricula. These are shown in Appendix 2.

The necessity for industrial experience is recognised, and in the four- and five-year full-time course students are required to work in industry during the summer vacations of the junior and senior years. Plant visits are also included to supplement vacation experience.

Conscious efforts are made to introduce realism into the class-room by the use of "projects", "case" studies and "situations".

2.3 Industrial Approaches

As previously mentioned there were two lines of thought on the function of the Industrial Engineering department, one administrative and the other non-administrative. In each case, of course, it was a staff function assisting line management. Also, irrespective of the ultimate responsibilities of the Industrial Engineering Department, agreement was unanimous on the functions performed under this designation.

With respect to recruitment for Industrial Engineering functions, again there were two main approaches, dependent on the existance or non-existance of a training scheme. Where no formal training scheme existed, graduates in Industrial Engineering were preferred for these functions and were usually placed in Methods Engineering, Time Study and Standards or Production Planning departments at the commencement of their employment, being rotated round each department over a period of years; the most proficient graduating to Special Projects eventually.

In one large company there were sixty graduates in Industrial Engineering employed in the Methods & Standards department whose total complement was one hundred and fifty personnel. This represented forty per cent, and the Chief Industrial Engineer was very well pleased with this type of graduate.

Most of the larger companies operated training programmes of one, two or three years' duration. These programmes were partly vocational and partly educational and were generally designed to suit the individual. After an initial basic training, work assignments were planned in accordance with desires and demonstrated ability. Companies with such training schemes did not display any great preference for Industrial Engineering graduates, but were more concerned with the soundness of the basic engineering education received. Graduates were not expected to be immediately productive and the companies preferred to give vocational training within the plant.

The Industrial Engineering Department was used in many cases as a training ground for young executives, since experience in this department facilitated transference to supervisory positions as the first step towards a factory executive.

2. 4. Professional Approaches

The professional organisation for Industrial Engineers is the American Institute of Industrial Engineers. This society has thirty senior chapters, twenty-one student chapters, and approximately 3,000 members. It has adopted the Canons of ethics of the National Society of Professional Engineers, which are stated in Appendix 3.

The purposes of the A.I.I.E. are :-

To maintain the practice of Industrial Engineering on a professional status,
To foster a high degree of integrity among the members of the industrial engineering profession,
To encourage and assist education among members of the profession,
To promote the interchange of ideas and information among members of the profession,
To serve in the public interest by the identification of men qualified to practice as industrial engineers,
To promote professional registration of Industrial Engineers.

In carrying out these purposes, a close working partnership is maintained with the Engineers Council for Professional Development. This Council was chartered as "a conference body organised to enhance the professional status of the engineer through the co-operative support of those national organisations directly representing the professional, technical, educational and legislative phases of an engineer's life". The participating organisations are:

The American Society of Civil Engineers
The American Institute of Mining & Metallurgical Engineers
The American Society of Mechanical Engineers
The American Institute of Electrical Engineers
The Engineering Institute of Canada
The American Society for Engineering Education
The American Institute of Chemical Engineers and
The National Council of State Boards of Engineering Examiners.

The expressed objective of the Council is the enhancement of the status of the engineering profession. A programme towards this end is being operated in which selection, guidance, training and recognition are the selected tasks. Much has already been done in improving and maintaining uniformity in selection by the initiation of a "Pre-engineering Inventory" to test the students' suitability for engineering education. Follow-up of student progress is maintained by "Engineering Achievement Tests" for second-year students, and tests are contemplated for student achievement at graduation. A further important aspect of the work of this Council is its system for "accrediting" engineering courses which meet a minimum standard assessed by the Education Committee of the Council.

At the request of a college for an assessment of a particular course, the Education Committee of the E.C.P.D. will make an investigation of the experience and attainments of the faculty, the standards and quality of instruction, the number and scholastic performance of its students, the records of graduates, the attitude and policy of administration, curricula, degrees conferred, physical facilities, etc., and if satisfied the course will be "accredited". There are fourty-four accredited courses in Industrial Engineering.

Developmenr of the graduate engineer during his early years in industry is encouraged by the formation of student chapters of the appropriate engineering institute, and by the implementation of a six-point programme relating to "The first Five Years of Professional Development". The six points of this programme are:-

Orientation and Training in Industry,
Continued Education,
Integration into the Community,
Professional Identification,
Self Appraisal
Selected Reading and Self Expression.

The recognition of the value of the continuation of education after graduating is illustrated by the following extract from the "Interim Report of the Committee on Evaluation of Engineering Education" (June 1954) which states:- "Education for the profession of engineering does not stop with the acquisition of a degree; it must continue throughout life. The most important goal of engineering education is to motivate the student to learn on his own intiative."

2.5. General Conclusions

Although one or two colleges are doubtful of the capability of raising the standard of teaching of some of the subjects in an Industrial Engineering curriculum to compare with those of other engineering departments, no one disputes the desirability of so doing. And without exception, at the colleges visited, efforts were being made to make the intellectual content of I.E. courses at least equal to other engineering departments.

There was general recognition that formalised education in the field of manufacture was as necessary as in the field of design or finance. Dispute may have arisen, however, on the stage at which this education should take place, whether graduate or undergraduate; but the different types of courses offered were adequate to cover the opposing views.

In the main industry favoured the Industrial Engineering courses, and many companies were very enthusiastic. Those which were indifferent were not unfavourable and without exception such companies operated an internal training programme.

Students are graduating at a rate exceeding 1,500 per annum and are being readily absorbed into industry. In 1953 over 1400 were enrolled for a Master's Degree, just under 1,000 being evening students.

From these facts it is apparent that education in Industrial Engineering is producing students capable of fulfilling an important function in industry. Proof of this is demonstrated by the results of one College which emphasises the administrative aspect of Industrial Engineering, and which now numbers 130 Presidents, 115 Vice Presidents, 83 Managers, 52 Partners and many other high executives among its alumni.

3. Education in Industrial Engineering*

1. Introduction

Considerable desire has been expressed by American educational bodies in recent years, for greater emphasis on the basic sciences and engineering sciences together with additional "liberal" education. This view was clearly stated by Dean Thorndike Saville in his presidential address before the American Society for Engineering Education in 1951:- "If we are 'to educate' as distinguished from 'to train' our future engineers", he said "I think we have to recognise more clearly the dual role which we have; that on the one hand as applied scientists we require even more fundamental science; that on the other hand as managers of industry and public works and as citizens we need more selection and breadth in our education".

The Society for the Promotion of Engineering Education appointed a committee which in 1940 submitted a "Report of Committee on Aims and Scope of Engineering Curricula'." In this the report recommended that the "broadening of the base of engineering education now in process should be continued. Its roots should extend more deeply into the social sciences and humanities, as well as into the physical sciences, in order to sustain a rounded educational growth which will continue into professional life". A later committee in 1944 reaffirmed the recommendation of 1940 that the curriculum be divided into two parts - the 'scientific-technological' and the humanistic-social' and outlined abjectives for both parts. As for objectives of the humanistic-social division, the report stated:- "We believe... that they can be achieved only through a designed sequence of courses extending through the four undergraduate years and requiring a minimum of approximately 20% of the students' educational time. This allotment should be at least equivalent to one three-hour course extending throughout the curriculum, and in the average somewhat more". As to subject matter, the report was specific:- "The subjects usually, and we believe properly, associated with the humanistic-social stem of the curriculum are found in the fields of history, economics and government, wherein knowledge is essential to competence as a citizen; and of literature, philosophy, psychology and fine arts, which afford means for broadening the engineers' intellectual outlook".

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*See Definition 2.1

No less strong was the endorsement given the social sciences and the humanities in 'Summary of Preliminary Report, Committee on Evaluation of Engineering Education" in 1953! which stated "The Committee recognises the importance of social studies and the humanities as an important part of an engineer's education. Such studies reveal the richness of human experience, so that the students may in turn enrich their own lives. They should trace the political, economic, and social history of mankind to give students a clearer perspective of our civilisation today. They should provide inspiration for seeking greater knowledge and understanding. They should aid the student to develop judgement and discrimination, a sense of value, and a sound personal philosphy".

Implementation of this worthy desire creates quite a strain on the normal four-year curriculum, and at least fifteen engineering colleges have adopted a five-year programme to effect a solution.

3.2 Types of Courses

A very wide variety of courses is offered in Industrial Engineering, some of the more common being:-

Four-year full time course leading to a Bachelor's degree
Five-year full time course leading to a Bachelor's degree
Five-year co-operative course leading to a Bachelor's degree
One-year post graduate course for I.E. graduates leading to a Master's degree
Two-year post graduate course for non I.E. graduates leading to a Master's degree
Three-year post graduate evening course leading to a Master's degree
Part time teaching and part time study courses leading to Master's and Doctor's degrees.

Four-year Full Time Course Leading to a Bachelor's Degree

This is the most common undergraduate couse, there being approximately 1,500 students enrolled in each of the current four years, i.e. a total of approximately 6,000 students. Each academic year is composed of two semesters, usually of 17 weeks each. The number of lecture hours per week is around 16, with the addition of two laboratory periods of three hours each.

Preparation for a lecture is generally assessed at two hours, thus weighting the value of one hour's lecture to be three hours' total study. Laboratory hours are not normally enhanced and only count as the actual hours spent. Hence the total designed study load placed on the student is 54 hours. This makes the grand total of hours of study at college 34 x 54 x 4 = 7544.

In addition it is normally required that students spend the summer vacations of the junior and senior years in industry.

Five-year Full Time Course Leading to a Bachelor's Degree

A number of Colleges believe that the desired inclusion of humanistic/social studies together with a deeper scientific/technological curriculum can best be met by the adoption of a five year programme for the Bachelor's degree. There are fifteen colleges currently operating this type of programme. No reduction is made on the student load per annum, therefore the grand total of hours of study is approximately 9180. It is also normal practice for the student to spend the final and penultimate vacations in industry.

Five-year Co-operative Course Leading to a Bachelor's Degree

The advantages of combining industrial training with education has been recognised by many of the American colleges, and co-operative courses are designed in an effort to derive optimum benefit from this association. There are 32 universities and colleges offering co-operative programmes at present.

The relationship of industrial training to education at college varies considerably between institutions, but in all cases the student is based at his college and is guided by a member of staff who co-ordinates his industrial training to match his academic education. To meet the desire for continuity in the industrial job, courses are generally divided to accommodate two groups of students, one group working in industry whilst the other is at college. On completion of the prescribed period, the groups interchange functions, thus continuity of the industrial job is maintained by two students working on an alternate basis.

No uniformity exists in the apportionment of time on the job or time at College, nor on the duration of the alternate phases. Although in a few cases alternation between college and industry commenced in the first year, this was not common, and in most courses students attended full time at college during the first year and, in many cases, also during the second year, before commencing industrial rotation. This arrangement enables the co-ordinator to assess the academic qualities of the student and to prepare, in consultation with the student, a co-operative programme most suitable to his individual abilities. Some of the various combinations of industry/college programmes are shown in Appendix 4.

In most colleges the total study hours approximate 7,000; however, there is considerable range in the industrial apportionment which varies from about 50 weeks to 144 weeks. No academic credit is granted for industrial training.

One Year Post Graduate Course for I.E. Graduates Leading to Master's Degree

Most colleges with an Industrial Engineering curriculum have provision for post graduate study of one further year to obtain a Master's degree. Courses are generally designed with an administrative or engineering bias in accordance with the student's desires and potential.

Approximately 500 day students were enrolled in 1953/4 for a Master's degree.

Two-year Post Graduate Course for Non I.E. Graduates Leading to a Master's Degree

A number of colleges offer post graduate cources in Industrial Engineering to students who have already graduated in one of the other engineering departments such as mechanical, electrical, chemical etc. Normally such courses require two years for completion.

Four-Year Post Graduate Evening Course Leading to a Master's Degree

Because of the large number of engineers wishing to proceed to a Master's degree on a part-time basis, a number of colleges provide an evening programme. Normally this requires four years for completion. During academic year 1953/4 there were approximately 900 students enrolled for a Master's degree under an evening programme.

Three-year Post Graduate Full Time Course Leading to a Doctor's Degree

Students who have shown potential for academic work during their Master's degree may be accepted for two years' further study for a Doctor's degree. There is no general course for the doctorate. The student must pass a comprehensive examination in his major field of specialisation before he will be recommended for candidature for the doctorate. A special doctoral committee is appointed for each applicant to supervise the work of the student, both as to selection of courses and to preparation of the dissertation. Generally a reading knowledge of German and French is required.

Part-time Teaching and Part-time Study Courses Leading to Master's and Doctor's Degrees

Many colleges offer teaching assistantships in which the Assistant devotes part of his time to studying for a higher degree.

The programme is designed to distribute the teaching/study load to give a uniform overall aggregate somewhat after the following fashion:-

Staff Position	Registration per Term
Full time	18 units
Half time	30 units
Third time	38 units

By this means selected graduates of good teaching potential are encouraged to join the teaching profession and to study for a higher degree.

3.3 Course Content

4-Year Full Time Undergraduate Course

Examination of the curricula of 7 colleges reveals much common subject classification, particularly in the first two years. Whilst the level of teaching may differ, the distribution of social/humanistic, basic science and engineering science subjects broadly agrees around 20, 60 and 20 per cent respectively in these two years.

Some colleges introduce technical or administrative subjects in the second year, but this is not customary until the third year. Commencing the third year, however, the basic sciences of chemistry and physics are replaced by technical and administrative subjects. The emphasis given to these subjects differs with the college, some colleges concentrating more on administration, others more on engineering or technology and others on mathematics as applied to industrial problems. There is no rigid line of demarcation, and indeed there may be a combination such as mathematical/administrative or mathematical/technical or engineering/technical etc. Appendix 5 shows the distribution of Subject Material of these courses.

To indicate the depth of course content, two colleges have been selected for deeper study, viz:- Massachusetts Institute of Technology (which may be classified as mathematical/administrative) and Syracuse University (mathematical/technological). These curricula are shown in Appendix 6, and details of the courses are shown in Appendix 7.

3.4 Teaching Method

Introduction

The desire to achieve the greatest effect from teaching was most apparent in all colleges, exemplified by the considerable degree of experimentation in teaching method practiced in an endeavour to increase the educational value of the course. This consciousness of the importance of teaching method was, no doubt, stimulated by the American Society for Engineering Education, which appointed a committee to report on the "improvement of teaching". The method adopted by the committee, to obtain information and to encourage discussion of teaching methods and their improvement, was to appoint over 100 faculty committees to submit reports on this subject. More than 150 reports, comments and suggestions were returned, demonstrative of the stimulus created.

Some of the salient points of the report follow:

"The primary objective of the study has been to consider how to prepare students to meet the new situations with skill, resourcefulness and leadership. Such preparation requires of the staff an understanding of the principles of teaching and learning, an appreciation of means for developing resourcefulness and originality, and continuing study of the most effective ways to achieve co-ordination of instruction. Principles of learning stress the importance of effective participation on the part of the learner; his motivation through the formulation of a goal; the clear definition of task assignments (preferably defined by the student himself); the evaluation of his progress; and his repeated practice in application. To raise the level of what the student does, it is emphasised that teaching should be from basic laws of science rather than from specially derived formulae.

"Engineering education provides the opportunity for related approaches in classroom, laboratory and design work. Full opportunity should be taken to co-ordinate these approaches. Similarly the social-humanistic stem can become more meaningful to the engineering student by co-ordination with the technical studies.

The rotation of instructors among the various subjects which come within their general professional field is recommended. Intelligently employed, this practice develops broader acquaintance with subject matter and promotes course co-ordination.

The teacher is the key factor in efforts to improve education. This should be fully appreciated by every administrative officer and should find expression in three major ways:

(1) Recruiting the most promising teachers
(2) Recognising good teaching in the most effective manner - advancement and adequate compensation, and
(3) Developing a specific plan for staff and committee discussion on methods of improving teaching so that the young instructor may benefit from the experiences of mature staff members.

Teaching loads should be kept within their prescribed limits in order to permit teachers at all levels to engage in creative research and other activities contributing to their professional development".

Among the specific methods adopted in the various colleges are:

Lecture recitation and laboratory
Quiz
Project
Case study
Situation
Industrial Visits
Field work
Creative thinking
Seminar.

Lecture, Recitation and Laboratory

Although this is a well-known method of imparting knowledge, there were some features in practice in American colleges well worthy of mention. No effort was spared to ensure maximum understanding of the subject. In some colleges lecture rooms were equipped with power facilities, dynamometers etc. to enable the apparatus to be demonstrated during the lecture.

In the machine tool series, actual machines were installed in the classroom and the salient features demonstrated simultaneously with the lecture. (See Appendix No.)

Subsequent to the lecture the class is sub-divided into smaller groups for recitation wherein the lecture is discussed and elaborated more informally. Students are encouraged to participate and contribute at these recitations.

Laboratory exercises are designed to supplement the lectures and copious instructions are supplied to the demonstrators or instructors on the material covered during the lecture and on the points for emphasis during the laboratory. By this means integration is obtained and a high level of education achieved.

Quiz

The quiz is a device adopted to motivate the student to a condition of mental alertness and to present him with a progressive evaluation of his performance. Quizzes are short written tests, generally of an hour's duration, and take place about once a month. They have the effect of keeping the student on his toes and enable the staff to grade the student at an early date and give counsel where required.

Project

The project method is designed to develop originality and resourcefulness in the student. It presupposes education in a number of fields and draws on this widespread knowledge, integrated to effect a solution to the project. Projects are generally introduced in the later years and take many forms to suit the subject matter and the level of the students. In the more practical sphere they may take the form of designing, process planning and manufacturing a machine tool or accessory, and in the managerial sphere a market survey may be made, followed by the design of the manufacturing facilities required for the production of the selected products. This method can be most valuable for co-ordinating a course.

Case Study

The case method is an attempt to introduce greater realism into education by presenting actual problems which have arisen in industry for analysis and solution by the class. This method was originated by Harvard School of Business Administration and is most effective when applied to post graduate students, with industrial experience.

Some colleges use the case method for undergraduate instruction, but greater care has to be exercised in such event in the selection of cases within the experience of the student.

If suitably chosen, to draw on the subject matter of a course of lectures, the case method can engender realism and develop the student's ability to grapple with a comprehensive problem. More will be said of the case method in the section on the Harvard School of Business Administration.

Situation

The "situation" is a development of the case method. Its purpose is to create more realism than the case method. For its success it requires the co-operation of industrialists who are prepared to visit the college and discuss with the class an unsatisfactory situation within their organisations which they intend to remedy.

The class is given the task of analysing the situation, extracting the problem, and offering solutions. After the elapse of a prescribed period the industrialist will re-visit the class, criticise their solutions and describe the actual action taken. This is an extremely valuable method of creating realism, and no doubt also has educational value to the participating industrialists.

Industrial Visits

Since few college students have industrial experience, plant visits are a very important teaching aid. These visits are generally planned in conjunction with the lectures and are arranged to illustrate the equipment in action.

A report on the visit is required from the student. Industrial visits are a very essential part of education in order to initiate the student into the industrial atmosphere and to demonstrate the ultimate goals of education.

Field Work

Field work is the most realistic of all methods as it brings the student into contact with industry. Again it requires the closest co-operation with industry and a high level of performance by the class. In this method a section of an organisation is selected for detailed investigation by the class and a report presented of their recommendations for improvement. Practice is gained in personnel relations in addition to the exercise of engineering ability.

This is an excellent method if adequate prestige can be achieved to induce industry to co-operate.

Creative Thinking

Since the pace of modern progress and the situations created are changing so rapidly, many colleges are searching for teaching methods which will develop original outlook and creative thinking in their students. Unusual situations are presented which require untrammelled thought for their solution. One example is a project in which a structure has to be designed for erection on the moon, where gravity and atmosphere differ considerably from the earth. This demands a different approach and compels the student to search fundamentally for a solution.

Credit must be given to many of the colleges for their efforts to develop flexibility of mind in their students and an ability to face and solve entirely new problems.

The Seminar

The seminar is generally only operated in the senior years or post graduate. It is a small discussion group with a staff member present to lead discussion if necessary. The objective is to encourage students to think and talk constructively, and simultaneously to elaborate on educational topics.

Properly handled, this method can be most valuable, as a situation can be engendered in which students can be made to feel that they are participating with the staff, and added interest can be created.

3.5 Faculty

Qualifications

The qualities desired in a faculty member are perhaps best illustrated by the following extract from the Interim Report of the Committee on Evaluation of Engineering Education, June 1954.

"The important quality that we look for in a faculty is evidence of professional stature and competence, including the kind of competence that may take any number of forms or combination of these. In the case of a fellow in his thirties, or even forties, we are interested to see if he has a doctorate since, if he has, it is evident that he has had sufficient scholarly interest to go on for graduate work and research. But the doctorate of itself is neither necessary nor sufficient evidence of the quality for which we are looking. It is not necessary because there are many young men of first rate ability who have elected not to take graduate work. We usually ask how it is that a man who is interested in education has not taken the rather natural route of graduate work and the resulting advanced degrees, but we are quite willing to be convinced that there are reasons not affecting his qualifications. On the other hand, the man may have the qualifications to earn and actually hold an advanced degree, and still not have the personal qualities or indeed the effectiveness in professional work that would qualify him well as a faculty member. Thus, while we use the doctoral degree as a quick, rough-and-ready indicator, it is an indicator rather than a measure of the qualities for which we are looking.

"In an older man, whose formal education took place at a time when advanced degrees in engineering, especially at the doctoral level, were comparatively rare, we would have even less basis for insisting upon a doctoral degree. In such a case we nearly always have to look to other criteria as a basis for appraisal.

"In a faculty of several members in a given department we are likely to expect to find from one to several members holding doctors' degrees, if the faculty is really good. However, it is perfectly possible that professional qualifications, of the sort I will mention in a moment, are sufficient to demonstrate excellence.

"Publication is another indicator of professional stature. Here again, the mere fact that a man has published a number of papers does not it itself have significance. One asks: were the papers good; did they make significant contributions; were they well regarded by competent men in the field; are any of them recent publications? If the publications are in the form of books, we ask, is the book recognised as making a genuine professional contribution either to the field or to the teaching of the field? On the other hand, is it merely a compilation in a different form of material already available in book form to the profession?

"Another indicator is the kind, if any, of professional work upon which the man is currently engaged. Does he have any investigatory activity under way? One important form of such investigatory activity is research.

Such research would usually, though not invariably, be carried out in the institution, either with institutional funds or some form of sponsorship from industry or government. If such work is under way, is it basically just testing? Is it puttering in its professional standards, or is it work that really digs into some new area and offers some promise of real contribution to the profession? This work may be applied or of a fundamental character. If applied, it should still have real intellectual challenge, involve imaginative exploration of new ideas, and in general be of such a nature that if it is well carried out, it should lead to publication, welcomed by the accepted professional journals in the field. Such research is always stimulated and facilitated if the staff member attracts graduate students as co-workers in such a project. Graduate students, however, are not essential. Such a project need not be large. It may, in fact, be quite modest in its physical and fiscal dimensions. The important point is the quality of intellectual effort involved and the professional significance of the investigation.

"The development of specific hardware may or may not represent good research activity in engineering. The test is not whether or not the product is produced in pilot model or other form, but rather the kind of professional effort that it required, and the level of professional competence that is demonstrated.

"Another possibly significant kind of professional work is consulting. We ask, is the man doing any consulting work? If he is, we again ask, is it of a routine character, or does it involve substantial responsibility? Is it concerned with some new development, or is he merely doing some handbook-arithmetic application of well-known principles in a routine fashion?

"Another indicator, and a very important one, is the kind of teaching that a man is doing. Is he continually revising the subjects that he teaches in response to the impact of new developments? This does not mean, for example, asking in the field of electrical engineering whether he is teaching television or not; rather it means, is he taking into account in his selection of the areas in the fundamental engineering science that he treats, the kinds of principles that one must understand if he is to have a basic understanding of the field of television? A continuing evolution of the teaching of even so elementary and fundamental a subject as electric circuit theory or electric field theory is evidence of a scholarly and active mind that we like to see in a teacher. We are sceptical of the man whose course has not changed very appreciably in the last ten years in the orientation, outlook and selection of subject matter. Again this most emphatically does not mean that we expect a professor to teach applications. It does mean that we expect his handling of fundamental courses to reflect in the selection of material, the selection of illustrative problems, and in the associated laboratory work, the needs of the fields that are active today in practice.

"The kind and quality of a man's teaching technique and the effect this has on his students, are significant. Here the eveidence is often hard to get, and necessarily rather intangible. Nevertheless, there are often indicators as to whether the man's class and laboratory teaching is of a character to stimulate the imagination of his students, to develop their initiative, to challenge their abilities, to broaden their outlook, to impose real responsibility on the student. The contrast with this is the teaching that conscientiously but without imagination, ingenuity or contribution of its own, follows the content of some standard text book.

"The problems a professor gives to his students are often very revealing of a professor's professional outlook, and the kind of influence that he is bringing to bear on his students. The home problem or laboratory exercise designed to pique the student's curiosity or to make him think out something different from what the textbook has shown, is a good indicator.

"The level of penetration of a professor's teaching provides meaningful indicators of his intellectual stature and the quality of his influence. Here we ask the questions: does his work have a large qualitative content, or does he emphasize more strongly the analytic, the mathematical, the scientific aspects? Does he cover the theory somewhat apologetically and superficially, merely to satisfy a conscience before getting to problem work and applications? Does he make free use of the calculus, and in the appropriate fields, even elementary differential equations, or does he stick to arithmetic and algebra alone? If he uses calculus, does he really understand it himself and use it with a reasonable degree of rigor? We feel that engineering schools offer an almost unique opportunity for a student to get the underlying theory and science, and that this school time is to a considerable extent wasted if it is devoted to qualitative, descriptive material in lieu of underlying fundamental theory.

"We, of course, recognise the importance of the mature individual of broad experience and notable wisdom who can convey to his students an important contribution to their character and to their entire outlook on their profession and life. We should not underrate such a person when we actually find him, but neither should we make the mistake of attributing these high qualities to the genial, personable good fellow who has long lost (if he ever had any) his vigor and technical acuteness. We must insist upon really acute and penetrating intellectual attributes and general technical astuteness of a superior sort to make our professor eligible for the true elder statesman category.

"Leaving teaching and turning again to other areas of activity: another indicator is the degree of participation of the faculty member in his professional society activities. By participation I mean not only attendance, but taking an active part in the meetings and activities. The fact of participation itself is not sufficient. One needs to know whether his participation relates to significant ideas and issues, or whether it is shallow and conventional. In what repute is the man held by his professional associates over the country? Is he known to them because of his professional contributions, or is his name unfamiliar?

"Industrial experience can, of course, be an important measure of professional qualification. We need, however, to look at the nature and character of this experience very closely to determine its relevance to engineering teaching, thus we look primarily, not at the number of years, or even the administrative responsibility that a man may have carried, but rather at evidence of intellectual qualities and activity that we feel are important in a teacher of engineering. Has he been responsible for significant new developments? Is he the sort of person who can be articulate in relating his engineering works to the underlying engineering science clearly and logically? Has his work been such that he has kept his underlying science and engineering science up-to-date and alive? Is his exposition clear and logical? Many practical engineers who achieve fine results do so by a kind of intuitive sense which, no matter how successful for a practical engineer, falls flat as far as effectiveness in teaching engineering students is concerned.

"Looking now at the overall appraisal, one cannot expect to find a high score for very many of the people on all of the above indicators of professional stature and competence. A good man, however, will score rather well on more than one of the foregoing categories, including one or more outside of teaching. The better the man, the higher his score and the more categories in which he will have a high score. Furthermore, in a good and well-rounded departmental faculty all of these qualities are present, though seldom in any single individual.

"One final word regarding the doctorate is perhaps not out of place, especially as the importance of this degree as a qualification for faculty appears to be so widely misunderstood. Doctorates are finding their place, and they have a place, a place of increasing importance in engineering education. But let's neither give them too much weight, nor ignore them completely. Rather let us try by all the measures we know to determine whether this fellow about whom we are talking is one to whom we really wish to expose our engineering students.

"Thus far we have emphasised primarily the qualities of the individual person at which one looks in attempting to appraise a faculty member. A fine faculty, however, consists of much more than a group of individuals and individualists, who would qualify well according to the foregoing criteria. The element of team play and team spirit is almost as important in an engineering faculty as it is on a college football team. Do the various faculty members work together harmoniously and co-operatively? We must not be misled by the dulcet sound of the words 'harmonious' and 'co-operative'. A very important test of these qualities is the ability of these individuals to differ with each other vigorously and earnestly in an intellectual sense, and indeed on problems of a more philosophic character, but to maintain in all this a degree of objectivity and personal goodwill that makes the friendly golf match or wilderness fishing trip together just as characteristic as strongly expressed differences of opinion and judgement. One looks for evidence of fairly achieved compromise in the common core of earlier courses and expects the curriculum as a whole to have a unity and singleness of purpose that provides strength. At the same time one looks for the tolerance that permits fine ability and special competence to have its head in elective subjects.

"One also looks for evidence of good leadership, leadership that insists upon a sound, well-rounded, forward-looking pattern in the curriculum and programme. Sometimes a fairly firm hand is indicated from a Dean to ensure that enthusiastic individualists take sufficient time and thought in joint and co-operative effort to ensure that their programme as a whole makes sense, that it points toward worthy and forward-looking objectives, and considers adequately and imaginatively the advancing fronts of the professional field. But through all the activity there should be evident a spirit of goodwill, of willingness for some personal sacrfice in the common good, and a sense of pulling together that nevertheless encourages expression of individual ability and energy".

3.6 Consultancy and Research

As outlined above, the faculty member is encouraged to develop his stature and to make a closer contact with industry by engaging in private consultancy work or research. Generally, one day per week is officially permitted for such activities. There were instances where this allowance was exceeded, but providing college work does not suffer and that the consulting work is of high calibre, such excesses are overlooked. Research work is mainly conducted during vacations, the faculty member being engaged and paid for this work.

University salaries are usually paid for 10 months of the year only, the remaining two months being at the disposal of the faculty to undertake research, consulting work or have a vacation.

In most colleges part-time assistantships are offered to graduate students of high calibre, their duties being divided between study and research. By this means good students are encouraged to proceed to higher degrees, and the level of academic teaching is consequently improved.

Teaching Load

The actual load imposed on faculty members is not uniform for many reasons. It was generally accepted, however, that a teaching schedule of 12 credit hours per week would be the maximum expected. This would mean 4 lecture hours and 8 recitation hours, but there was no case encountered where the actual load was so heavy. In most instances it was very much lighter.

Allowances are made if additional work is being undertaken by the faculty member, for instance teaching load may be reduced by half of the maximum if sponsored research is being done; similarly supervision of masters' theses and the preparation of technical literature claim a reduction in teaching load, as do administratvie duties.

Faculties were encouraged to expand on their professional and academic fields, as this was rightly deemed to increase their stature, and consequently the value of their teaching, and teaching loads were reduced accordingly.

3.7 Summary

The most significant feature of education in Industrial Engineering was its magnitude. In 1954 nearly 8,000 students were enrolled in Industrial Engineering courses in 84 schools. This was the fifth largest group and was only exceeded by Mechanical, Electrical, Civil and Chemical engineering.

Without exception a sound education in the basic and engineering sciences formed the foundation of the Industrial Engineering curriculum. Again, all schools were striving to ensure that the course has as high an intellectual content as the older established engineering courses. It was felt that most schools had been successful in this endeavour.

The exceptionally wide variety of courses offered catered for the circumstances of almost every class of student, and the co-operative course satisfied the combined requirements of the student and industry. Accumulating the subject material in the three types of courses, technical, administrative and mathematical, the range was very extensive indeed, and it was obviously not possible to treat the total in four years' course, hence the tendency to concentrate on one or two phases only. However, it was again felt that the range of courses offered ensured adequate education in all the major aspects of Industrial Engineering.

No effort was too great to advance the quality of teaching and most faculty members were trying new approaches to improve the educational value of their work. Equipment was abundant and helped considerably to increase the learning of the student.

One could not help being impressed by the competence and enthusiasm of the faculties. Without exception faculties were most competent and had widespread contacts with industry and all other sections of their departments. Most members were active in their professional societies, and attendance at society meetings was a very stimulating experience arising from the high level of discussion.

In conclusion, it was most apparent that American industry recognised that formal training in Industrial Engineering was as necessary as in other fields, and was absorbing I.E. graduates at a rate exceeding 1,500 per annum. That a high level of education was being given in this subject was acknowledged by most industrialists consulted.

3.8 Comparison with related courses in Great Britian

Few courses entirely comparable with Industrial Engineering exist in Great Britain, and in the main those most closely resembling Industrial Engineering are post-graduate.

Undergraduate Courses:

A number of universities include some I.E. subjects in their undergraduate mechanical engineering programmes; for example:

Birmingham University includes Engineering Economics.
Cambridge University includes Industrial Administration and Economics.
Durham University includes Engineering Administration.
Edinburgh University includes Organisation of industry and Commerce.
Glasgow University includes as optional subjects: Engineering Economics, Engineering Production, Industrial Psychology.
Leeds University includes Applied Economics, Production Engineering, Engineering Production and Administration.
Manchester University offers an honours course in Production Engineering.
Nottingham University includes Industrial Administration.
Sheffield University includes Manufacture and Management.
Cardiff University, College of South Wales & Monmouthshire includes Industrial relations.
Glasgow Royal Technical College includes Engineering Prodution.

In addition, many Technical Colleges offer a Higher National Certificate Course in Production Engineering which has some relation to the I.E. courses with technical bias.

Examples of types of courses in Great Britain related to Industrial Engineering

3 or 4 years University Course leading to an Engineering Degree.
4-years Technical College sandwich course leading to a Higher National Diplomain Production Engineering.
2-years full time Technical College course leading to a Higher National Diploma in Prodution Engineering.
5-years part time day course leading to a Higher National Certificate in Production Engineering.
5-years evening course leading to Higher National Certificate in Production Engineering.

Comparison of Course Content

3 years University Course leading to Honours Degree in Production Engg.

Manchester University offer the above course which is probably the nearest approach at undergraduate level to an Industrial Engineering course.

The curriculum and details of the course are shown in Appendix 8.

Comparison with the undergraduate courses detailed in Appendix 8 reveals that the First Year course of an American University would be necessary before admission to the threeyears degree course as evidenced by the similarity between the Preparatory course at Manchester University outlined in Appendix 8, and the First Year American courses in Appendix 6. Hence, for comparison of course content, the Preparatory course at Manchester has been included.

A summary of the curricula of Course XVA, Business and Engineering Administration at M.I.T., Industrial Engineering Course at Syracuse University and the Production Engineering Honours Course at Manchester University is shown in Appendix 9.

Examination of the course content reveals the Manchester University Course as having a strong bias in basic and engineering sciences. Apart from the humanities, it is only in the technical and administrative groups that the balance is in favour of the American courses.

The subjects in these latter groups notincluded in the Manchester Course are:

M.I.T.

Industrial Management
Economic Principles
Accounting
Marketing
Personnel Administration
Finance

Electives

Industrial Relatiins
Economics
Government & Public Administration
Prices & Production
Economics of Invention
International Trade
Union Management Relations
Management Laboratory

Syracuse University

Engineering Economic Analysis.

Some aspects of Industrial Management are included in the Manchester course, but at M.I.T. emphasis is placed on the broader business aspects of profit, analysis of demand, price policies, fluctuations in economic activity, wage policy and public policy. Indeed more emphasis is placed on economic aspects in most American courses, and Engineering Economic Analysis is taught in most colleges. Some details of this course are shown in Appendix 20.

With the exception of Engineering Economic Analysis and Humanities, there is no subject taught at Syracuse University that is not treated at Manchester University. At M.I.T. there is more education given in the business and economic aspects, and whilst the basic science and engineering content is greater than in most other American Universities, this is much less than in the Manchester Course. Indeed, the excess time given to these sciences in the Manchester Course is almost balanced by the time given to business and economics at M.I.T.

4-year Technical College Sandwich Course leading to a Higher National Diploma in Production Engineering

Some Technical Colleges offer a six months' sandwich course in which the student alternates between industry and College. In most courses the student is based in industry, and co-ordination of practical training is dependent on industry.

The course at Birmingham College of Technology is shown in Appendix 10. The subject matter contained in this course is comparable with the Manchester University course in Appendix 8. This course is also strong in the basic and engineering sciences as the Manchester Course, but in addition more time is given to the technical subjects.

Weakness is again shown in the administrative subjects and in lack of emphasis placed on the economic aspects of industry.

In this programme the Intermediate Course bears resemblance to the First Year American Courses, and has been included when comparing course content.

Part-time Day Course leading to the Higher National Certificate in Production Engineering

The part-time Day Course is the most common type of course. Normally it takes five years of study through courses S1, S2 and S3 leading to the Ordinary National Certificate, then Courses A1 and A2 leading to the Higher National Certificate.

In order to maintain some degree of equality of student education at entry, in the various courses being compared, it is considered that course S3 is comparable in level with the Intermediate year of the Diploma Sandwich course, and the curriculum at Birmingham College of Technology in Appendix 11 is prepared accordingly.

Examination of this curriculum reveals its concentration on Mathematics, Engineering and Technology. Even with this restriction the total hours of the course at 702 is less than those devoted to these three categories at M.I.T., where the total is 704, and at Syracuse University where the total is 1106 hours.

This type of course is more comparable with that offered by the Bridgeport Engineering Institute shown in Appendix 13, which has similarity with the Higher National Course in Mechanical Engineering. No degree is conferred for completion of this course at Bridgeport, but a diploma is awarded.

Evening Course leading to a Higher National Certificate in Production Engineering

The evening course (Appendix 12) is slightly narrower in subject matter than the part-time day course, and the total hours is reduced to 513, therefore in this case there is less time spent on these few categories - maths, engineering and technology - than is given to the same categories in most American universities. As mentioned previously, this type of course is more comparable with the type given by Bridgeport Engineering Institute shown in Appendix 13. However, even in the latter course more total time is given, as in the three final years 895 hours are credited, 140 being given to administration, economics and English.

Summary of Courses

H.N.C. Production Engineering Evening Course.
H.N.C. Production Engineering part-time day course.
H.N. Diploma (sandwich) Course in Production Engineering.
Honours Degree Course in Production Engineering.
Bridgeport (Connecticut, U.S.A.) Engineering Institute Evening Course in Mechanical Engineering.
Syracuse University Course in Industrial Engineering.
M.I.T. Course in Business and Engineering Administration.

Appendix 14 shows a graphical summary of the content of the above courses grouped into the broad categories - mathematics, engineering, technical, administrative, physics, chemistry, humanities and project or thesis.

In compiling the total credit hours in a course, the American system in which 1 lecture hour = 1 credit hour, and 3 laboratory hours = 1 credit hour, has been adopted. Also, in order to achieve a measure of uniformity of student level at entry, the following assumptions have been made:-

(i) Entrance standards for first year courses at Syracuse and M.I.T. to be alike.

(ii) Preparatory Course at Manchester University to be equivalent to first year courses at M.I.T. and Syracuse.

(iii) Intermediate (sandwich) course at Birmingham College of Technology to be equivalent to first year at M.I.T. and Syracuse.

(iv) S3 course of H.N.C. part-time day and evening courses to be equivalent to first year course at M.I.T. and Syracuse.

Obviously there will not be complete uniformity in these assumptions, but a comparison of the contents of the courses indicates an acceptable measure of agreement.

H.N.C. Courses

On the above basis it is apparent that neither the H.N.C. part-time day course, nor the H.N.C. Evening Course can be seriously compared with the degree courses in America. The total credit hours in the evening course is only 513, and in the part-time day course only 702, whilst at Syracuse University mathematics and engineering alone account for 734, and at M.I.T. the same two categories account for 690 hours.

It would be more appropriate to compare the H.N.C. Courses with the type given by the Bridgeport Engineering Institute (as shown in Appendix 13) which bears close resemblance to our H.N.C. course for Mechanical Engineering.

Desirable as it may be to introduce some Industrial Engineering subjects such as engineering economics, work study, engineering statistics, production planning and control, it is apparent that it would be unwise to do so at the expense of time now spent on the basic and engineering sciences.

H.N. Diploma (Sandwich) Course

A totally different picture obtains in this type of course, where the total credit hours, at 2766, exceeds those of Syracuse University (2138) and M.I.T. (2010) by a considerable margin. Only in the administrative subjects are the credit hours significantly less. This is not considered a serious disadvantage at undergraduate level, but the emphasis given by the American courses to the economic aspects of production as in Engineering Economic Analysis is certainly desirable.

Another notable feature of American Education is the orientation of the courses in mathematics, to the treatment of production problems involving game theory, linear programming, Monte Carlo, and other techniques embraced within Operations Research. Such inclusions where the mathematical background is adequate are deemed most desirable. An H.N. Diploma sandwich course pitched as suggested would compare favourably with most courses in Industrial Engineering. Coupled with the industrial experience gained during the six months per year at work makes this a most attractive course for the education of sound Production Engineers capable of advancing to management at an early date.

It is regrettable that only about 40 students were enrolled in this type of course in 1953-4.

Honours Course in Production Engineering

This course also compares favourably with the American courses, and similar remarks made regarding the Sandwich Course, relating to the introduction of operation research techniques and emphasis on the economic aspects of manufacture are the only comments necessary.

Again it is regrettable that there are very few courses of this type, and the number of students attending such courses is only 4.

Comparison of Number of Students in U.S.A. and U.K. (England & Wales) taking Courses in Industrial Engineering or U.K. equivalent

Appendix 16 compares graphically the number of U.S.A. students attending Industrial Engineering day courses, and U.K. students attending University or H.N. Diploma Sandwich Courses in Production Engineering. It is obvious that the U.K. total is insignificant in comparison. Even the addition of the total number of students enrolled in the H.N.C. part-time day course (which is not equivalent) does not redress the deficiency (allowing for population difference).

Post Graduate Courses in Production Engineering

One Year Course:

The Universitites of Durham, Manchester, Glasgow and Birmingham offer one-year post-graduate courses in Production Engineering, although Birmingham University call their course Engineering Production. The contents of the latter course are shown in Appendix 17. Entrance requirement for this course is a Science Degree and satisfactory industrial experience, but other students with equivalent qualifications are eligible for admission.

Such entrance qualification enables the course to concentrate on the economic, technical, operational research and administrative aspects of industry. Hence the addition of this type of course to an engineering degree or H.N.D. engineering course would compare very favourably with American courses. If taken by good H.N.C. engineering students the whole course would then be in alignment with the Industrial Engineering courses.

There are 17 students enrolled for the one-year post-graduate course, plus five working for higher degrees.

It is proposed to offer a one-year course in Industrial Engineering at the College of Aeronautics, Cranfield. The syllabus of this course is shown in Appendix 18.

Two-Year Course:

The College of Aeronautics, Cranfield, offer a two-year course in Economics and Production. This course is designed mainly for graduate or H.N. students from the aircraft industry, thus in addition to the Industrial Engineering subjects as outlined in Appendix 18, the following subjects are included:- Aerodynamics, Mathematics, Aircraft Design, Propulsion, Electrical Engineering, Flight and Materials.

There are 26 students enrolled in the first and second years.

Conclusions and Recommendations

"Industrial Engineering" is a well-established University subject, recruiting students at a rate such that it will soon outstrip the older engineering subjects in total students. The fact that more than 1500 Industrial Engineering students per annum are at present graduating from American universities assists considerably in invigorating industry with fresh minds trained to deal with the ever-increasing complexity of production and business problems. The existence of such a group of University trained production staff no doubt contributes to the flexibility and adaptability of American industry to new and better ideas, and substantially reduces, if not eliminates, the gap between research and production.

Formal education in Industrial Engineering or, as understood in this country, Production Engineering plus Industrial Administration, is most desirable in order to supply trained engineers capable of eventually managing the post of Vice President of Manufacturing, as shown in Figs. 1 and 2, more often called Works or Production Manager in this country, and working effectively at all lower levels on graduation from College.

A survey of the broad field of education in Production Enginering (which is the nearest equivalent to Industrial Engineering) silhouettes in sharp relief the narrowness of out H.N. Certificate Courses in Production Engineering relative to the American courses. Only by the addition of a course in Industrial Administration as outlined in Appendix 15, does the teaching content bear comparison with Industrial Engineering. Hence it may be said:- H.N.C. Production Engineering + Diploma Industrial Administration = Industrial Engineering. This sequence is regarded as the most effective, although it has the very serious drawback of requiring a minimum of seven years' study from S2 level.

For this reason and for the benefit of more concentrated study, the Sandwich Course is much more attractive. This type of course for Production Engineers has much to offer, as the contact with industry each year indoctrinates the student into industrial conditions and facilitates his eventual placement in industry with the minimum disturbance. Such a course should be planned between the employer, the college and the student, in order to derive maximum co-ordination and the greatest educational value. It may be necessary to encourage students and employers to accept such a course by the provision of scholarships by the Education Authorities. Some scheme similar to the Co-operative scheme in U.S.A. in which two students man the same job in industry, one being on the job whilst the other is at college, and vice versa, may avoid any disruption in industry during the educational period.

The Sandwich Course and the Degree Course cover most of the subject material given in courses in Industrial Engineering, but emphasis on Economic Engineering and Operational Research would be advantageous.

Summary of Recommendations

Types of Courses:

Efforts should be made to encourage students and industry to adopt the Sandwich type of course to a much greater extent than at present. If all students now taking the H.N.C. part-time course in Production Engineering were diverted to the Sandwich Course, the combined total would only approximate 1300, compared with 6600 American students taking Industrial Engineering. (See Appendices 14 & 16).

More post-graduate courses of one year's duration, similar to that in "Engineering Production" at Birmingham University should be made available for students with a Science Degree who have inclinations towards production and management.

Course Content:

No drastic change is recommended in course content; however, emphasis on the economic aspects of industry should be made at all stages where appropriate, and should be introduced at H.N.C. level into tool design and machine tools. In the Sandwich and Degree courses, where the mathematical background is adequate, the introduction of operations research techniques is recommended.

Teaching Method:

Faculties should be encouraged to search for more effective teaching methods and should be invited to report their recommendations.

Faculty:

Research and consultancy should be encouraged and teaching loads should be adjusted to permit this. By this means closer contact with industry's needs would be maintained and increase in stature of faculty should result, with consequent improvement in educational capability.

Industry

The importance of formal education in production engineering and administration should be made more widely known to industrialists, so that greater encouragement may be given to employees to follow such a course. The rapid development even now proceeding in production and control techniques requires a flexibility of mind capable of accepting and installing new methods and managing their associated problems. Since the rate of scientific development is accelerating, it is more necessary than ever that the supply of production and administrative engineers is adequate to translate scientific discovery into production reality on the required scale.

Teacher Exchange

Greater facilities should be made available for teacher exchange schemes at technical college and University level between U.S.A. and this country. Advantages could be derived by both countries from such an arrangement, since although most American universities were strong in administrative subjects, not all were strong in production engineering, such as process planning, estimating, tool design, metrology - subjects which our colleges particularly emphasise.

Acknowledgements

So considerable has been the benefit derived from this visit, that it is not possible to express adequately the gratitude due to the U.S. Foreign Operations Administration for their goodwill and generosity in making such visits possible to foreign educators. Likewise it is difficult to thank fully all the persons consulted who, without exception, have been unstinting in their help to make the visit beneficial. It is therefore hoped that all concerned will accept this general acknowledgement of gratitude.

Special thanks are due to the Project Managers, S.M. Patterson and R. J. Young, of the Education Branch, Technical Assistance Training Staff, F.O.A., and J. W. Gresson Jr., Programme Officer and Acting Chief Technical Training Section, Department of Health, Education and Welfare, Office of Education, who prepared and directed the overall programme, and to A.B. Dickeman of Syracuse University, who organised the Syracuse programme; also to R.O. Swalen of Syracuse University for his continuous assistance throughout the project, and to W.V.A. Clark of M.I.T. for organising the M.I.T. programme.

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APPENDIX 1

PROGRAMME OF VISITS

EDUCATIONAL

June 6th - 9th, 1954	Syracuse University, New York State.
June 12th - 17th.	Conference of American Society for Engineering Education at University of Illinois, Urbana.
June 19th - 21st	Summer School of A.S.E.E. at University of Illinois, Navy Pier, Chicago.
June 22nd	Center for Study of Liberal Education for Adults, Chicago.
June 23rd	University of Cincinnati, Cincinnati.
June 26th	Ohio State University, Columbus.
June 28th	Carnegie Technical Institute, Pittsburgh.
June 30th	Case Institute of Technology, Cleveland.
July 1st	University of Michigan, Ann Arbor.
July 7th	Harvard University, Cambridge.
July 8th and 12th	Massachusetts Institute of Technology, Cambridge.
July 9th	Northeastern University, Boston.
August 4th	Institute of Industrial Research, Syracuse University.
August 6th	Cornell University, Ithaca.
August 9th/Sept. 3rd	"Executive Controls" Course, Syracuse University.
September 10th	University of California, Los Angeles.
Sept. 21st/Nov.12th	Massachusetts Institute of Technology, Cambridge.
November 4th	Wentworth Institute of Technology, Boston.

INDUSTRIAL

June 10th	General Electric Co., Electronics Park, Syracuse.
June 18th	International Harvester Company, Chicago.
June 24th	Cincinnati Milling Machine Co., Cincinnati.
June 29th	United States Steel Company, Pittsburgh.
June 30th	Thompson Products Inc., Cleveland.
July 13th	United Shoe Machinery Co., Boston.
July 14th	New Process Gear Corporation, Syracuse.
July 15th	Carrier Corporation, Syracuse.
July 16th	Lamson Corporation, Syracuse.
July 21st	Rollway Bearing Co., Syracuse.
July 22nd - 23rd	Eastman Kodak, Rochester.
August 3rd	Manufacturers Association, Syracuse.
September 7th	Convair Aircraft Corporation, San Diego.
September 8th, 9th and 13th	Lockheed Aircraft Corporation, Los Angeles.
September 10th	Douglas Aircraft Co., Santa Monica.
September 14th	Ford Aircraft Division, Chicago.
September 16th	Glenn L. Martin Company, Baltimore.
September 17th	Westinghouse Electric Co., Philadelphia.
November 12th	General Electric Co., Lynn, Mass.

1.1

Persons Consulted

Syracuse University, New York State

College of Business Administration

Morris E. Hurley, M.B.A.	Dean of College of Business Administration.
Maurice C. Cross, A.B., M.A., Ph.D.	Professor of Industrial Management.
Donald A. Ferguson, M.B.A., Ph.D.	Associate Professor of Finance.
Alfred W. Swinyard, M.B.A.	Associate Professor of Marketing.
Allen B. Dickerman, A.B., M.B.A.	Assistant Professor of Production Management. (Programme Officer at Syracuse Univ. for this Project).
Howard T. Lewis Jr., B.A.,M.B.A.	Assistant Professor of Production Management.
William Wasserman, A.B., M.A., Ph.D.	Assistant Professor of Business Economics and Statistics.

College of Engineering

Ralph A. Galbraith, B.S.E.E., Ph.D.	Dean of College of Industrial Engineering.
Bert H. Norem, B.S.M.E.,M.S.M.E.	Professor & Department Chairman - Industrial Engineering.
Dakota E. Greenwald, M.A., Ph.D., B.S.M.E.	Associate Professor of Industrial Engineering.
Joseph V. McKenna, B.A.Sc., M.M.E.	Associate Professor of Industrial Engineering.
Ralph O. Swalm, B.S.E.E.	Associate Professor of Industrial Engineering.

University of Illinois

Urbana

K. J. Trigger.	Professor in Industrial Engineering.
B. T. Chao.	Associate Professor in Industrial Engineering.
G. E. Schrader.	Assistant Professor in Industrial Engineering.

Navy Pier, Chicago

J. S. Kozacka.	Professor in Mechanical Engineering.
R. W. Schroeder.	Associate Professor in Mechanical Engineering.
R. B. Perkins.	Associate Professor in Mechanical Engineering.

University of Cincinnati, Cincinnati

C. Albert Joerger, M.E.	Dean, College of Engineering.
Francis H. Bird, Ph.D.	Dean, College of Business Administration.

Norwood C. Geis, Com.E., A.M., C.P.A.	Assistant Dean, College of Business Administration.
Leslie Swallie.	Assistant Professor of Co-ordination.

Carnegie Technical Institute, Pittsburgh

George Leland Bach.	Dean, Graduate School of Industrial Administration.
Abraham Charnes.	Associate Professor of Mathematics and Economics.
William Robert Taaffe.	Associate Professor of Industrial Administration.

Massachusetts Institute of Technology - Cambridge

School of Industrial Management

Edward P. Brooks, S.B.	Professor of Industrial Management, Dean.
Erwin H. Schell, S.B.	Professor of Industrial Management.
Billy Goetz, Ph.D.	Professor of Industrial Management
Gerald B. Tallman, Ph.D.	Associate Professor of Marketing.
W. Van Alan Clark Jr., B.A., S.M.	Associate Professor of Industrial Management.
Herbert F. Goodwin, S.B.	Associate Professor of Production Management.
Leo B. Moore, S.M.	Assistant Professor of Industrial Management.
Robert B. Fetter, D.C.S.	Assistant Professor of Industrial Management.
Thomson M. Whitin, Ph.D.	Assistant Professor of Industrial Management.
Edward H. Bowman, S.B., M.B.A.	Instructor in Industrial Management.
Albert H. Rubenstein, M.S.	Instructor in Industrial Management.

Engineering School

J. P. Den Hartog, Ph.D.	Professor of Mechanical Engineering.
G. S. Brown, Sc.D.	Professor of Electrical Engineering.
Earle Buckingham.	Professor of Mechanical Engineering, Emeritus.
M. C. Shaw, Sc.D.	Professor of Mechanical Engineering.
P. A. Smith, S.B.	Associate Professor of Mechanical Engineering.
E. G. Loewen, Sc.D.	Assistant Professor of Mechanical Engineering.
W. A. Bachofen, Sc.D.	Assistant Professor of Metallurgy.
G. P. Wadsworth, Ph.D.	Associate Professor of Mathematics.
C. L. Svenson, S.M.	Associate Professor of Heat Engineering.

W. A. Lynan, Ph.D., Professor of Mechanical Engineering, Case Institute of Technology, Cleveland.

C. B. Gordy, Ph.D., Professor of Industrial Engineering, Univ. of Michigan, Ann Arbor.

O. W. Boston, M.S.E., M.E., Professor of Production Engineering, Univ. of Michigan, Ann Arbor.

P. R. Visser, B.S.E. (M.E.), Instructor in Production Engineering, Univ. of Michigan, Ann Arbor.

F. E. Folts, A.B., M.B.A., A.M. (hon) Professor of Industrial Management, Harvard University.

W. T. Alexander, S.B., M.A., Dean of College of Engineering, Northeastern University, Boston.

W. Keating, Ph.D., Professor of Industrial Engineering, Northeastern University, Boston.

T. P. Wright, Ph.D., President, Cornell University, Ithaca.

M. W. Salmson, Ph.D., Professor Industrial Engineering, Cornell University, Ithaca.

R. M. Barnes, Ph.D., Professor of Production Management, Cornell University, Ithaca.

R. A. Wilder, Head of Department of Machine & Tool Design, Wentworth Institute, Boston.

APPENDIX 2

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS, INC.

National Headquarters
145 North High Street
Columbus 15, Ohio

Colleges and Universities having Industrial Engineering curricula accredited by The Engineers' Council for Professional Development (as of September 30, 1953):

Name	Location
Alabama, University of *	University, Alabama
California, University of *	Berkeley, California
Columbia University *	New York, New York
Florida, University of *	Gainesville, Florida
Georgia Institute of Technology *	Atlanta, Georgia
Illinois Institute of Technology *	Chicago, Illinois
Lafayette College	Easton, Pennsylvania
Lehigh University *	Bethlehem, Pennsylvania
Massachusetts Institute of Technology	Cambridge, Massachusetts
Michigan, University of	Ann Arbor, Michigan
Montana State College *	Bozeman, Montana
New York University *	New York, N.Y.
North Carolina State College *	Raleigh, North Carolina
Northeastern University *	Boston, Massachusetts
Northwestern University *	Evanston, Illinois
Ohio State University *	Columbus, Ohio
Oklahoma A & M College *	Stillwater, Oklahoma
Oregon State College	Corvallis, Oregon
Pennsylvania State College	State College, Penn.
Pittsburgh, University of *	Pittsburgh, Pennsylvania
Rensselaer Polytechnic Institute	Troy, New York
Rutgers University *	New Brunswick, N.J.
Stanford, University	Stanford, California
Syracuse University *	Syracuse, New York
Tennessee, University of *	Knoxville, Tennessee
Texas, A & M College of *	College Station, Texas
Texas Technological College *	Lubbock, Texas
Virginia Polytechnic Institute *	Blacksburg, Virginia
Washington University *	St. Louis, Missouri
West Virginia University	Morgantown, W. Va.

* Student Chapter of American Institute of Industrial Engineers or Chapter organizing group.

Colleges and Universities having Industrial Engineering options as part of other Accredited Curricula (E.C.P.D. reports as of 9/30/53):

College or University	Location
Akron, University of	Akron, Ohio
Clarkson College of Technology	Potsdam, N.Y.
Cornell University	Ithaca, N.Y.
Iowa, State University of	Iowa City, Iowa
Kansas State College	Manhattan, Kansas
Kansas, University of	Lawrence, Kansas
Louisiana State University	Baton Rouge, La.
Massachusetts, University of	Amherst, Mass.
Ohio University	Athens, Ohio
Purdue University	Lafayette, Ind.
Santa Clara, University of	Santa Clara, Calif.
Toledo, University of	Toledo, Ohio
Washington, University of	Seattle, Washington
Wayne University	Detroit 1, Michigan

APPENDIX 3

CANONS OF ETHICS FOR ENGINEERS

Foreword

Honesty, justice, and courtesy form a moral philosophy which, associated with mutual interest among men, constitutes the foundation of ethics. The engineer should recognize such a standard, not in passive observance, but as a set of dynamic principles guiding his conduct and way of life. It is his duty to practice his profession according to these Canons of Ethics.

As the keystone of professional conduct is integrity, the engineer will discharge his duties with fidelity to the public, his employers, and clients, and with fairness and impartiality to all. It is his duty to interest himself in public welfare and to be ready to apply his special knowledge for the benefit of mankind. He should uphold the honor and dignity of his profession and also avoid association with any enterprise of questionable character. In his dealings with fellow engineers he should be fair and tolerant.

Professional Life

Sec. 1. The engineer will co-operate in extending the effectiveness of the engineering profession by interchanging information and experience with other engineers and students and by contributing to the work of engineering societies, schools, and the scientific and engineering press.

Sec. 2. He will not advertise his work or merit in a self-laudatory manner, and he will avoid all conduct or practice likely to discredit or do injury to the dignity and honor of his profession.

Relations with the Public

Sec. 3. The engineer will endeavor to extend public knowledge of engineering, and will discourage the spreading of untrue, unfair, and exaggerated statements regarding engineering.

Sec. 4. He will have due regard for the safety of life and health of the public and employees who may be affected by the work for which he is responsible.

Sec. 5. He will express an opinion only when it is founded on adequate knowledge and honest conviction while he is serving as a witness before a court, commission, or other tribunal.

Sec. 6. He will not issue ex parte statements, criticisms, or arguments on matters connected with public policy which are inspired or paid for by private interests, unless he indicates on whose behalf he is making the statement.

Sec. 7. He will refrain from expressing publicly an opinion on an engineering subject unless he is informed as to the facts relating thereto.

Relations With Clients and Employers

Sec. 8. The engineer will act in professional matters for each client or employer as a faithful agent or trustee.

Sec. 9. He will act with fairness and justice between his client or employer and the contractor when dealing with contracts.

Sec.10. He will make his status clear to his client or employer before undertaking an engagement if he may be called upon to decide on the use of inventions, apparatus, or any other thing in which he may have a financial interest.

Sec.11. He will guard against conditions that are dangerous or threatening to life, limb, or property on work for which he is responsible, or if he is not responsible, will promptly call such conditions to the attention of those who are responsible.

Sec.12. He will present clearly the consequences to be expected from deviations proposed if his engineering judgment is overruled by nontechnical authority in cases where he is responsible for the technical adequacy of engineering work.

Sec.13. He will engage, or advise his client or employer to engage, and he will co-operate with, other experts and specialists whenever the client's or employer's interests are best served by such service.

Sec.14. He will disclose no information concerning the business affairs or technical processes of clients or employers without their consent.

Sec.15. He will not accept compensation, financial or otherwise, from more than one interested party for the same service, or for services pertaining to the same work, without the consent of all interested parties.

Sec.16. He will not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with his client or employer in connection with work for which he is responsible.

Sec.17. He will not be financially interested in the bids as or of a contractor on competitive work for which he is employed as an engineer unless he has the consent of his client or employer.

Sec.18. He will promptly disclose to his client or employer any interest in a business which may compete with or affect the business of his client or employer. He will not allow an interest in any business to affect his his decision regarding engineering work for which he is employed, or which he may be called upon to perform.

Relations With Engineers

Sec.19. The engineer will endeavor to protect the engineering profession collectively and individually from misrepresentation and misunderstanding.

Sec.20. He will take care that credit for engineering work is given to those to whom credit is properly due.

Sec.21. He will uphold the principle of appropriate and adequate compensation for those engaged in engineering work, including those in subordinate capacities, as being in the public interest and maintaining the standards of the profession.

Sec.22. He will endeavor to provide opportunity for the professional development and advancement of engineers in his employ.

Sec.23. He will not directly or indirectly injure the professional reputation, prospects, or practice of another engineer. However, if he considers that an engineer is guilty of unethical, illegal, or unfair practice, he will present the information to the proper authority for action.

Sec.24. He will exercise due restraint in criticizing another engineer's work in public, recognizing the fact that the engineering societies and the engineering press provide the proper forum for technical discussions and criticism.

Sec.25. He will not try to supplant another engineer in a particular employment after becoming aware that definite steps have been taken toward the other's employment.

Sec.26. He will not compete with another engineer on the basis of charges for work by underbidding, through reducing his normal fees after having after having been informed of the charges named by the other.

Sec.27. He will not use the advantages of a salaried position to compete unfairly with another engineer.

Sec.28. He will not become associated in responsibility for work with engineers who do not conform to ethical practices.

APPENDIX 4

5 Years Co-operative Courses

Northeastern University

First Year - College only - 3 terms - 30 weeks
Second Year) 10 weeks College, 10 weeks industry
Third Year) 10 weeks College, 16 weeks industry
Fourth Year) 5 weeks College
Fifth Year) Total 25 weeks College - 26 weeks industry
per year per year

Total Study hours for 5 years Course = 7020 hours
Total weeks in industry = 104 weeks

University of Cincinnati

First Year - 35 weeks College - 8 weeks industry
Second Year) 7 weeks College - 8 weeks industry
Third Year) 7 weeks College - 8 weeks industry
Fourth Year) 7 weeks College - 10 weeks industry
Fifth Year) Total 21 weeks College - 26 weeks industry
per year per year

Total Study hours for 5 years Course = 6426 hours
Total weeks in industry = 112 weeks

University of Minnesota

First Year - College only - 33 weeks
Second Year - College only - 33 weeks
Third Year) 11 weeks College - 11 weeks industry
Fourth Year) 11 weeks College - 11 weeks industry
Fifth Year) Total 22 weeks College - 22 weeks industry
per year per year

Total Study hours for 5 years Course = 7128 hours
Total weeks in industry = 66 weeks

APPENDIX 5

Table of Industrial Engineering Subjects for 7 Colleges

	First Semester	Syracuse	Michigan	Illinois	U.C.L.A.	M.I.T.	Carnegie	Case
Social/ Humanistic	(English	3	4	3	3		3	3
	(Western Civilisation					3	3	
	(Background of Democracy							3
Maths.	(Algebra, Trigonometry	3	4	5	3		4	4
	(Calculus	3				3		
Chem.	General Chemistry	4	5	4	5	4	3	4
Physics	Physics					4		3
Engineering	Engineering Graphics	3	3	3	2	2	1	2
Orientation	Engineering Orientation	1			1			

Second Semester

	Second Semester	Syracuse	Michigan	Illinois	U.C.L.A.	M.I.T.	Carnegie	Case
Social/ Humanistic	(Background of Democracy							3
	(English	3	4	3			3	3
	(Western Civilisation					3	3	
Maths.	Calculus	3	4	3	3	3	3	4
Chem.	General Chemistry	4	5	4	3	4	3	4
Physics	General Physics	4		4	4	4	3	3
Engineering	(Engineering Graphics	3	3	3	2	2	1	2
	(Surveying				3			

Third Semester

	Third Semester	Syracuse	Michigan	Illinois	U.C.L.A.	M.I.T.	Carnegie	Case
Social/ Humanistic	(Western Civilisation							4
	(Structure of American Economy	6						
	(Effective speaking		2		3			
	(U.S.A. Ideas and Men					3		
	(Change in Modern Soc.						3	
Maths.	Calculus	4	4	5	3	3	3	3
Physics	Physics	4	5	4	4	4	3	4
Engineering	(Engineering Mechanics	3	3	2		3	3	3
	(Metallurgy				3			
	(Engineering Drawing		2		2			4
Technical	(Materials Casting			3				
	(Machine Tools				2			2
Administrative	(Economics			3				
	(Industrial Management					3	3	

	Fourth Semester	Syracuse	Michigan	Illinois	U.C.L.A.	M.I.T.	Carnegie	Case
Social/ Humanistic	(Western Civilisation							4
	(Operation of American Economy	6						
	(Mod. Western Ideas and Values					3		
	(Government Processes						3	
	(Non-technical elective			2				
Maths.	(Calculus	4	4		3		4	3
	(Problems and Operations analysis					3		
Physics	Physics	4	5	4	4	4	4	4
Engineering	(Engineering Mechanics	3	4	3	3	3	3	2
	(Electrical Engineering		2					
	(Strength of Materials			3				4
	(Advanced Drawing		2	2				
Technical	Metal Processing			3	4			2
Administrative	(Industrial Management					3		
	(Economic Analysis						3	

	Fifth Semester	Syracuse	Michigan Management	Michigan Production	Illinois	U.C.L.A.	M.I.T.	Carnegie	Case
Social/ Humanistic	(Western Civilisation								
	(Social Humanistic	3			3		3	3	
Maths.	(Mathematics			3				3	
	(Statistics				3				
Engineering	(Thermodynamics		6		3	3	3	4	5
	(Strength of Materials	4				4			
	(Structure of Metals			2	1		4		
	(Metals and Alloys								
	((Properties)			3					
	(Fluid Mechanics								4
	(Dynamics		3	3		3		3	
	(Machine Design		3	3	5				
	(Electrical Engineering	4	4			4			
Technical	(Manufacturing Processes	4							
	(Machining		3	3					
	(Casting			3					
	(Industrial Engineering	3							3
Admini-strative	(Industrial Administration				3				
	(Business Administration		3			3		3	
	(Cost Accountancy		3	3			3	3	
	(Marketing						3		
	Sixth Semester								
Social/ Humanistic	(Western Civilisation								4
	(Government Business							3	
	(Social Humanistic	3					3	3	
Maths.	(Engineering Analysis							3	
	(Engineering Statistics	3							
Engineering	(Electrical Engineering	4						3	4
	(Thermodynamics			2		3	3		5
	(Fluid Mechanics					3	3		
	(Advanced Machine Design		3	3	3	4			5
	(Mechanical Eng. Lab.				3				
Technical	(Production Methods	4							2
	(Machining			3					
	(Hydraulic Machinery		3						
	(Casting		2						
	(Metallurgical Operations			3	3				
	(Plant Visits & Reports	2							
	(Plant Layout & Mech. Hand.		3						
	(Motion & Time Study		3		3				
	(Job evaluation & Incentives								
Admini-strative	(Industrial Management			3			3		
	(Personnel Administration						3		
	(Cost Accounting		3	3	3	3		3	
	Electives				3		3		

	Seventh Semester	Syracuse	Michigan Management	Michigan Production	Illinois	U.C.L.A.	M.I.T.	Carnegie	Case
Social/ Humanistic	(Social/Humanistic								3
	(Report Writing			2		2			
	(Social Humanistic				3		4		
	(Foundation of Law							2	
Maths.	Mathematics			3		3			
Engineering	(Thermodynamics	4				3			4
	(Chem. & Met. Engg.		3						
	(Fluid Mechanics			3					
	(Electrical Engineering			4	4		4		4
	(Machine Design				3				
	(Strength of Materials							1	
Technical	(Industrial Eng. Seminar	3							
	(Motion & Time Study	3				3			
	(Machining		3						
	(Indust. Est. & Costs	2							
	(Prod. Planning & Control	3						3	
	(Job Evaluation & Incentives		2						
	(Process Planning & Tool Design				3	3			
	(Technical Elective	3	3	2	3		4		4
Admini- strative	(Business Administration		3			3		3	
	(Economics		3	3				3	
	(Professional Elective						4		4
	(Marketing							3	
	Thesis						2		
	Eighth Semester								
Social/ Humanistic	(Social Humanistic	3		3	3		4	3	3
	(Technical Report		2			6			
Maths.	(Quality Control	2							
	(Engineering Analysis							3	
Engineering	(Fluid Mechanics	4							
	(Metals & Alloys								4
	(Industrial Electronics						4		2
	(Mechanical Engineering								3
Technical	(Engineering Econ. Anal.	3	2	2		3			
	(Indust. Plant Design	3			3				
	(Design for Production			2					
	(Indust. Engineering				1	3			
	(Wage Incentives					2			
	(Process Instrumentation			2					
	(Safety Engineering				3				
	(Technical Elective	3	6	6	6				4
	(Production Control		2					2	
Admini- strative	(Personnel Admin.		3	3					
	(Admin. & Organisation					3		3	
	(Finance							3	
	(Accounting							3	
	Professional Elective						3		4
	Thesis						4		

	Elective Subjects	Syracuse	Michigan	Illinois	U.C.L.A.	M.I.T.	Carnegie	Case
Social/ Humanistic	Political Science				3			
Maths.	(Advanced Engineering Stats.	3				3		4
	(Statistical Theory					3		
	(Higher Maths for Engineers	3						
Engineering	(Applied Mechanics	3				4		
	(Heat Transfer	2						
	(Fluid Mechanics					3		
Technical	(Adv. Motion & Time Study	3						
	(Materials Handling	2						
	(Job Evaluation & Wage Incentives			3				
	(Welding Engineering			3				3
	(Experimental Investigation			3				
	(Production Processes and Inspection			3				
	(Product Development		3					
	(Industrial Engineering		2					4
	(Process Equipment Selection		3					
	(Thesis			3				
Administrative	(Marketing	3				3		
	(Finance	3				3		
	(Accounting	3				3		
	(Industrial Relations	3				3		
	(Business Law	3						
	(Production Co-ordination			3				4
	(Industrial Management		3					
	(Industrial Procurement		3					
	(Business Administration				3			
	(Economics				3	3		
	(Govt. & Public Administration					3		
	(Prices and Production					3		
	(Economics of Invention					3		
	(International Trade					3		
	(Union Management Relations					3		
	(Management Laboratory					3		
	(Production Control							4
	Military Science						1	

APPENDIX 6

Curricula for 4 years undergraduate courses in Industrial Engineering or Comparable course

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Course XV-A and XV-B
Business and Engineering Administration

FIRST YEAR COURSE (Common to schools of Engineering, Science, Humanities and Social Studies and Industrial Management)

First Term			Second Term		
5.01[1]	Chemistry, General	7-4[2]	5.02	Chemistry, General	7-4
8.01	Physics	5-6	8.02	Physics	5-6
H11	Western Civilisation, Foundations	3-5	H12	Western Civilisation Foundations	3-5
M11	Calculus	3-6	M12	Calculus	3-6
MS11	Military Science	3-0	MS12	Military Science	3-0
	Additional Subject[3]	0to6		Additional Subject	0to6
		42to48			42to48

[1]This number identifies the subject.

[2]These numbers indicate the credit hours obtainable, (1 credit hour representing 1 hour per week for 15 weeks). The first number shows the number of hours of class instruction per week and the second the number of hours credited for preparation.

[3]Students in the schools of Engineering and Industrial Management are recommended to choose one of the following as an additional subject:-

D11	Engineering Drawing	4-2	D12	Descriptive Geometry	4-2
D13	Graphical Processes	2-4	D13	Graphical Processes	2-4

SECOND YEAR COURSE

First Term			Second Term		
2.001	Applied Mechanics I	3-5	2.002	Applied Mechanics II	3-5
2.85	Machine Tools Int.	4-1	8.04	Physics	5-5
8.03	Physics	5-5	15.02	Indust. Man.II Fund	3-6
15.01	Indust. Man.I Fund	3-6	H22	Humanities	3-5
H21	Humanities	3-5	M221	Prob. & Ops. Anal.	3-6
M21	Calculus	3-6	MS22	Military Science	3-0
MS21	Military Science	3-0			
		24-28			20-27

Required During Summer.
Industrial or Business Practice.

THIRD YEAR COURSE

First Term			Second Term		
2.40	Heat Engineering	4-5	1.601	Fluid Mechanics	3-6
3.11	Engineering Metals	6-4	2.42	Heat Engineering	3-6
14.01	Econ. Prin. I - Humanities	3-5	15.30	Personnel Admin.	3-6
15.50	Accounting	5-4	15.71	Production Man.	3-6
15.81	Marketing	3-6		Humanities	3-5
				Hum. or Prof. or Eng. Elect. Subj.	8
		21-24			52

FOURTH YEAR COURSE

First Term			Second Term		
6.18	Electrical Eng. Fund	4-6	6.19	Indust. Electronics	4-6
15.41	Finance	3-6		Thesis	10
	Thesis	2		Humanities	3-5
	Humanities	3-5		Hum. or Prof. Elective	8
	Engg Elective Subj.	9		Prof. Elective Subj.	9
	Prof. " "	9			
		47			45

Business and Engineering Administration Electives

15.42	Financial Institutions	Term 2	3-6
15.51	Industrial Accounting	Terms 1 & 2	3-2-4*
15.61	Business Law	Terms 1 & 2	3-6
15.65	Labour Law	Term 1	3-6
15.72T	Work Measurement	Term 1	3-3-3
15.73	Management Laboratory	Terms 1 & 2	3-3-3
15.74	Management Lab. Adv.	Term 2	3-3-3
15.82	Sales Promotion	Term 2	3-6
15.83	Marketing Research	Term 1	3-6
15.90	Technique of Exec. Control	Term 2	3-6
15.92	Industrial Problems	Term 1	3-6

* 3 hours lecture. 2 hours laboratory. 4 hours preparation.

SYRACUSE UNIVERSITY
Industrial Engineering Course

FIRST YEAR (Common to all engineering courses)

First Term	Credit Hours
Freshman English (English 1a)	3
College Algebra (Maths. 20)	3
Calculus I (Maths. 21)	3
General Chemistry (Chem. 6a)	4
Engineering Graphics (E.D. 14)	3
Engineering Orientation (E.O.)	1
Physical Ed. or R.O.T.C.	1 or 2
Total Hours	18 or 19

Second Term	
Freshman English (English 1b)	3
Calculus II (Maths. 22)	3
General Physics (Physics 31)	4
General Chemistry (Chem. 6b)	4
Engineering Graphics II (E.D. 15)	3
Physical Ed. or R.O.T.C.	1 or 2
Total Hours	18 or 19

SECOND YEAR

First Term	
Calculus III (Maths. 23)	4
General Physics (Physics 32)	4
Engineering Mechanics (M.E. 29)	3
Social Humanistic	6
Physical Ed. or R.O.T.C.	1 or 2
Total Hours	18 or 19

Second Term	
Calculus IV (Maths. 24)	4
General Physics (Physics 33)	4
Engineering Mechanics (M.E. 31)	3
Social Humanistic	6
Physical Ed. or R.O.T.C.	1 or 2
Total Hours	18 or 19

THIRD YEAR

First Term	Credit Hours
Manufacturing Processes (I.E. 120)	3
Mfg. Processes Lab. (I.E. 121)	1
Industrial Engineering (I.E. 102)	3
Mechanics of Materials (C.E. 53)	3
Materials Testing Lab. (C.E. 49)	1
Princ. of Electrical Engineering (E.E. 45)	4
Elective - Social Humanistic	3
Total Hours	18

Second Term	
Production Methods (I.E. 122)	3
Production Methods Lab. (I.E. 123)	1
Ind. Plant Visits & Reports (I.E. 106)	2
J.E. and Wage Incentives (E.E. 115)	2
Eng. Statistics (Maths. 128)	3
Princ. of Electrical Engineering (E.E. 46)	4
Elective - Social Humanistic	3
Total Hours	18

FOURTH YEAR

First Term	
Thermodynamics (M.E. 60)	3
Mechanical Engineering (M.E. 70a)	1
Ind. Eng. Seminar (I.E. 150)	3
Motion & Time Study (I.E. 160)	3
Industrial Estimating (I.E. 170)	2
Prod. Planning and Control (I.E. 180)	3
Elective - Technical	3
Total Hours	18

Second Term	
Fluid Mechanics (C.E. 51)	4
Eng Econ. Analysis (I.E. 175)	3
Quality Control (I.E. 185)	2
Ind. Plant Layout (I.E. 190)	3
Elective - Technical	3
Elective - Social Humanistic	3
Total Hours	18

APPENDIX 7

Details of Courses

4 Years Undergraduate Courses in I.E.

Massachusetts Institute of Technology

Courses XV-A and XV-B

Business and Engineering Administration

The philosophy underlying this course is that sound training in engineering is a pre-requisite for good business administration. An extract from the M.I.T. catalogue makes this view very clear: "Not only is it apparent that the successful management of industrial enterprises demands ability to understand and cope with technological problems of ever-increasing complexity, but it is believed that fundamental training in science and engineering inculcates habits of precise thinking which are of great value in the study of all aspects of business administration".

Some justification for this viewpoint is borne out by the impressive list of top executive positions held by the graduatesof this course. This includes 130 Presidents, 115 Vice Presidents, 83 Managers, 52 Partners and many more.

Two courses are offered:- XV-A which is based on the Physical Sciences, and XV-B based on Chemical Sciences. Each course is identical in its business and humanities subject content.

The attitude adopted in teaching these courses is well described by a further extract from the M.I.T. catalogue:- "Courses XV-A and XV-B are designed to place emphasis on subject matter of a fundamental nature and to discourage concentration on any one professional engineering field. It has been concluded that within the limits of a four-year programme, development of a secondary engineering speciality is incompatible with the primary objective of sound professional education for administration".

Course XV-A

First Year

The first year course for the School of Industrial Management is common with the schools of Engineering Science, Humanities and Social Studies, and is detailed in Appendix 6.11.

Chemistry Courses 5.01 and 5.02

The lecture text books used for these courses are:- Hildebrand and Powell's 'Principles of Chemistry' and Lattimer and Hildebrand's 'Reference Book of Inorganic Chemistry'. For laboratory work Bray, Latimer and Powell's book 'A course in General Chemistry' is used.

Problem sheets are issued at each lecture and a set of these, together with the detailed lecture schedules is shown in Appendix 19, Sections 1-4.

The content of the Chemistry course is continuously being brought into line with modern requirements and more emphasis is being given to the structure of atoms and the shape of molecules in the present courses.

Physics Courses 8.01 and 8.02

The text book used in these courses is 'Mechanics Heat and Sound' by Professor Sears. Some departure is made in the sequence of presenting the subject matter and some consideration is being given to a slight revision of the material in course 8.01, but in the main this text book provides the basic groundwork. Appendix 19, Section 5, outlines the programme for course 8.02.

Calculus Courses M11 and M12

The text book for these courses is 'Calculus and Analytic Geometry' by Thomas. The detailed schedules of lectures are shown in Appendix 19, Sections 6 and 7.

Foundations of Western Civilisation H11 and H12

From readings in history, literature and philosophy, a study is made of the individual in his relationship to society and of the moral and intellectual problems involved in this relationship.

Engineering Drawing D11

This course is divided into two sections:-

A. Representational Graphics. This treats drawing as a means of communication and covers orthogonal, isometric and perspective representation.

B. Analytical Graphics. The development of a graphical mode of thought for the solution of physical problems is the aim of this course. Application of graphics to the solution of geometrical constructions, empirical curves, calculus is also emphasised.

Descriptive Geometry D12

This subject is designed to develop a capacity to think in space terms and analyses three dimensional space relations on a two-dimensional surface.

Graphical Processes D13

This is a recent course and it illustrates the significance being attributed to graphical solutions of physical problems. It develops more fully the treatment given in D11 to geometric constructions, calculus and empirical curves solved by graphical methods. Appendix 19, section 8, gives the schedule of subject material treated.

Second Year

Applied Mechanics I, 2.001 and Applied Mechanics II, 2.002

In course 2.001 the subjects treated are statics and Strength of Materials.

The text books used are 'Mechanics. Part I: Statics' by J. L. Meriam, and 'Elements of Strength and Materials' by Timoshenko and MacCullough.

An outline of the instructions schedule is shown in Appendix 19, Section 9, Course 2.002 continues with 'Strength of Materials' using the same text book, and also deals with 'Dynamics' using J. L. Meriam's text book 'Mechanics Part 2: Dynamics'. The teaching schedule is shown in Appendix 19, Section 10.

Physics 8.03 and 8.04

Course 8.03 deals with Electricity and Magnetism, using Prof. F. Bitter's text book 'Currents, Fields and Particles'. The lecture schedule is given in Appendix 19, Section 11. Course 8.04 continues with the same text book and treats Optics and Atomic Physics.

A problem sheet for this course is given in Appendix 19, Section 12.

Calculus M21

This course continues with the text book 'Calculus and Analytic Geometry' by T. G. Thomas, and also uses 'Mathematical Tables and Formulas' by Burrington. The lecture schedule is shown in Appendix 19, Section 13.

Probability and Operations Analyses M221

This is a new course and deals with Mathematical theory and techniques suitable for application to business and industrial problems. The subject matter includes linear differential equations with constant coefficients, Gamma and Beta functions, probability, distribution theory and expelled values. No text book is used at present, but much of the material is used from 'Notes from M.I.T. Summer Course in Operations Research', June 16 - July 3, 1953.

Introduction to Machine Tools 2.85

The basic machine tools are discussed and demonstrated in this course. During the discussion the actual machine is situated in the classroom and its principle features demonstrated. Laboratory exercises are given in most of the primary machining processes. Measurement inspection and quality control are also introduced. The text book used is 'Advanced Machine Work' by Smith.

Exercise sheets presenting problems in measurement, Time Study, production economics, dimensioning and standardisation, process analysis, tool design and estimating are of a very practical and educational nature.

Humanities H21 and H22

Two options are provided in these courses:-

A The United States: Ideas and Men. This deals with the problems and forces involved in the formation of the Union and its perpetuation.

B. Modern Western Ideas and Values. Readings in great books on religion, philosophy, science, political economy and literary classics are covered in this course.

Industrial Management Fundamentals I and II, 15.01 and 15.02

Course 15.01 introduces the student to the management of the business enterprise and deals with profit, analysis of demand, cost analysis, pricing and price policies, fluctuations in economic activity, wage policy and public policy.

The texts used are:- 'Business Economics' by Alt and Bradford, and 'Readings in Economics' by Mulcahy. The lecture programme is shown in Appendix 19, Section 14.

Course 15.02 deals with the managerial aspects and embraces Scientific management, managerial principles and philosophy, market research, business forecasting, Standards costs, planning for stability of operation and labour relations. Emphasis is placed on statistics, which constitutes about 25% of class time.

The text used is Moroney's 'Facts About Figures'; material is drawn from the bibliography in Appendix 19, Section 15. These courses are supplemented by case studies.

Third Year

Fluid Mechanics 1.601

This course deals with the elementary mechanics of incompressible and compressible fluids. The text book used is 'Basic Mechanics of Fluids' by Rouse and Howe, and the detailed lecture programme is shown in Appendix 19, Section 16.

Heat Engineering 2.40 and 2.42

In course 2.40 treatment is given to the properties of liquids, vapours, gases, gas mixtures and mixtures of air and water vapour. First and Second Laws of Thermodynamics, applications to closed systems and to fluids in steady flow. Keenan's text book 'Thermodynamics' is used and the lecture schedule is shown in appendix 19, section 17.

Course 2.42 continues with Keenan's text book and deals with reciprocating steam engines and turbines, power plant cycles, thermodynamics of chemistry, gas turbine processes etc. The lecture programme is outlined in Appendix 19, Section 18.

Engineering Metals 3.11

This course uses the text book 'Metallurgy for engineers' by Wulff, Taylor and Shaler, emphasising the effect of composition and mode of fabrication on the structure of metals and alloys, also their properties and engineering uses and the effect of heat treatment. Comparison is made with the processing of plastics. The lecture schedule is shown in Appendix 19, Section 19.

Economic Principles I - Humanities 14.01

This course introduces the student to fundamental economic concepts such as production, money, banking, labour, business organisation, international trade, government fiscal policy, with emphasis on the level and fluctuations in national income and employment.

The text used is Samuelson's ' Economics' and 'Readings in Economics' by Samuelson, Bishop and Coleman. Samuelson's book on Economics is a modern treatment, and an outline of the materials covered is shown in Appendix 19, Section 20.

Personnel Administration 15.30

Case studies are used in this course to test or develop constructive personnel policies. Studies are made of the plant as a social system; the basic problem of the worker's attitude to authority; manpower problems; management-union relationships; job evaluation; wage administration etc.

Finance 15.41

In this course the principles of financial organisation and management are treated, embracing the modern business corporation, corporate securities, investment banking and exchanges, problems of international financial control, tax aspects of financial management.

The texts used are:- 'Modern Corporation Finance' by Anderson, and 'Introduction to Business Finance' by Howard and Uton. The latter is a modern book treating the subject from an administrative point of view. The Course Schedule is shown in Appendix 19, Section 21.

Accounting 15.50

An introduction is given into the ways accounting may serve as a tool of management. Methods of gathering, synthesizing and presenting business data,with emphasis on problems of valuation and earnings determination, are studied. The application of both concepts and methods to the solution of business problems is tested.

Owing to the short time available for accounting instruction, the course is biased towards financial accounting, as this is required for subsequent courses in finance. It is also argued that Cost Accounting will generally be practiced at an early stage in business, thus providing education in this field, whereas the same is unlikely with Financial Accounting.

The text used is 'Accounting: A Management Approach' by Robnett, Hill and Beckett. The Assignment Sheet is shown in Appendix 19, Section 22.

Production Mangement 15.71

This course applies the principles of scientific mangement to the development of effective policies and techniques in administrative analysis, production control, materials control, standardisation and simplification. The emphasis is in the 'economics of production' as opposed to the engineering of production. Some of the methods and theories covered are:- experimentation; standards measurement and specification; graphical analysis - flow process charts, man-machine charts, operator charts; optimum quantities - marginal analysis, maxima and minima; expected values - uncertainty, probability and Monte Carlo; linear programming and allocations; information flow and feed back systems; statistical control, equipment replacement analysis - alternative costs. Typical problems analysed are:- production and inventory control, scheduling, purchasing, machine replacement, time standards, work simplification, maintenance, materials selection and quality control.

Bibliography used in the course is shown in Appendix 19, Section 23.

Marketing 15.81

The broad social and economic apsects are treated as well as the management problems associated with marketing. Instruction is primarily by the problem method, supplemented by reading assignments and conferences and marketing executives.

Fourth Year

Fundamentals of Electrical Engineering 6.18

Fundamental principles of electric and magnetic circuits and the application of these principles to the theory and performance of D.C. and A.C. machines. Presentation of the basic elements common to the electrical field, illustrated and amplified by association with engineering applications. Classroom instruction supplemented by experimental work in the electrical engineering laboratories.

Text book: Fitzgerald, 'Basic Electrical Engineering'.

Industrial Electronics 6.19

Continuation of course 6.18. Electron tube parameters and equivalent circuits, theory of simple amplifier, oscillator, rectifier, photoelectric cell, gas-filled tube circuits and brief survey of electrical measurement and control techniques.

Text book: Fitxgerald, 'Basic Electrical Engineering'.

Engineering Electives

Applied Mechanics III, 2.003 - 1 term, 4 hours lectures, 8 prep.

Plane dynamics, work and energy, impulse and momentum, angular momentum, gyroscope, free and forced vibrations with 1, 2 and 3 degrees of freedom. Vibrations of distributed mass systems. Elastic stability and buckling. Energy methods in elasticity and vibrations.

Fluid Mechanics 2.252T - 1 term, 3 hours lecture, 6 prep.

One-dimensional compressible flow with applications to problems associated with the design of turbojets, ramjets, rockets, combustion chambers, supersonic inlets, supersonic wind tunnels, gas turbines and steam turbines. Unsteady fluid motions, design and performance of radial and axial flow pumps, compressors, turbines and jet pumps.

Financial Institutions 15.42

This course approaches financial institutions from a businessman's viewpoint and analyses various types of banks, investment and trust companies, insurance companies, security exchanges and bookers, finance companies, financial agencies of government and international financial institutions.

Industrial Accounting 15.51

A study is made of the methods of organising cost data, and alternative courses of action are evaluated, together with planning and business programmes and control of current operations.

Case material is used from a wide range of commercial and industrial situations.

Business Law 15.61

An elementary study is made of the important legal problems involved in operating a business enterprise. Some of the aspects treated are:- performance and discharge of contracts, the Statute of frauds, agency and employment relationships, provision of the Uniform Negotiable Instruments Act, rights and duties of parties in various banking transactions, organisation of corporations, duties and responsibilities of management.

The texts used are:- 'Fundamentals of Business Law' by Frank, Smith, Stone and Romig, and 'Basic Contract Law' by Fuller. Some of the class material is shown in Appendix 19, Section 24.

Labour Law 15.65

In this course the following reports are studied: fundamental principles underlying the formation and operation of labour unions, the limitations on the right to strike and the right to boycott, and the control of union and employer activities through administrative governmental activities.

Work Measurement 15.72T

This was a new course not previously given and had the following objectives: to study the range and to measure human capacities in industrial situations, determine factors affecting work output; human engineering in relation to design of machines, tools and workplace, motion economy and the analysis of time measurement techniques.

Management Laboratory 15.73

This course deals with some of the practical tools of management and includes: Work simplification, motion study, standardisation process charts, layout, labour saving devices. Considerable emphasis is placed on human relations and worker participation. This course is organised mainly as conferences with students participating in every stage.

Advanced Management Laboratory 15.74

The course deals with advanced techniques in work simplification and motion study, with special emphasis upon management procedures followed in introducing and demonstrating analytical techniques to administrators, executives and employees; the organisation and operation of work simplification training programmes, co-ordination with suggestion schemes and maintenance of progress schedules and records of waste elimination.

Sales Promotion 15.82

This course deals with market research and planning; selection training and control of salesmen; sales promotion and advertising media; the effect of price policy on promotional problems.

The class is divided into committees, who report on specific assignments in the sales promotion area. The texts used are: 'Advertising, Text and Cases' by N. H. Borden, and 'Sales Management' by D. M. Phelps.

Marketing Research 15.83

In this course the basic principles of market research are studied. Field studies are conducted by the class and training is given in planning the investigation, development of questionnaire, collection and interpretation of data, techniques of analysis and presentation, and the preparation of written reports. A project is formulated by the class and the instructor and committees assigned to particular aspects.

Technique of Executive Control 15.90

A survey is made of an executive's duties and the means by which a line executive deals with the working group. An examination is made of the nature of the executive attitude, responsibilities and methods of supervision, also of devices to stimulate the desire of employees to improve quanitity and quality of work. Co-operation with other executives and functional specialists and the public is also studied.

Text books used are: 'Planning and Developing the Company Organisation Structure' by Ernest Dale (A.M.A.), 'Human Relations in Administration' by Robert Dubin (Prentice Hall), and 'Technique of Executive Control' by Erwin Haskell Schell (McG). The class programme is shown in Appendix 19, Section 25.

Industrial Problems 15.92

This is a course integrating marketing, production administration, product and process engineering, labour relations and financial control, and is mainly in-plant investigation. The planning of the investigation is done in class and techniques of analyses and presentations are discussed.

The reading list for this course is shown in Appendix 19, Section 26.

7.2 Syracuse University

Industrial Engineering Course

In common with most other courses in Industrial Engineering, a sound engineering training forms the basis of the course, as illustrated by the following extract from the College bulletin:- "The industrial engineer is first of all a good engineer. His program begins with a ground work in engineering fundamentals made up of (1) basic sciences: mathematics, chemistry and physics; (2) basic engineering subjects: drawing mechanics, materials of engineering, thermodynamics, electrical engineering, fluid mechanics, and (3) those elements of other engineering fields needed by all engineers. To those are added the specialised courses in Industrial Engineering that prepare him for work in production control, factory layout, methods improvement, motion and time study, quality control, job evaluation, wage administration, and cost reduction surveys."

Details of Course

First Year

1. Freshman English (3)
Composition and literature. Required of all students in the University. Prerequisite to all other English courses.

20. College Algebra (3)
Topics from college algebra and trigonometric analysis.

21. Calculus I. (3)
Concept of function, limit, derivative; analytic geometry of line and circle; application of derivative.

22. Calculus II. (3)
Definite integral and applications; derivatives of trigonometric functions; polar co-ordinates.

6. General Chemistry (8)
Experimental lectures, recitations and laboratory work. Fundamental principles and laws underlying chemical action, developed from the laboratory viewpoint and including semi-micro qualitative analysis. Two one-hour lectures, recitations and two two-hour laboratories per week.

31. General Physics (4)
The first semester of a three-semester course for all engineering students, covering the field of mechanics. Lectures, recitations and laboratory. Pre-requisite: Maths.22 as a parallel course.

1b The operation of the American Economy (3)

A study of the operation of the American Economy with emphasis on those aspects of direct significance to the individual as a citizen living in the economic community. Major problems and issues connected with the operation of the price system, the impact of fluctuations in income, production and employment, and international economic relationships.

Third Year

120. Manufacturing Processes (3)

Analytical study of the manufacturing processes employed by industry to fabricate the articles of our civilisation. The course includes the processing of commonly used metals, glass, porcelain, ceramics, textiles, wood, wood products and plastics. Emphasis is placed upon the determination of mechanical forces required in forming, spacial relationships in processing, and computations required in setting up machine tools. Prerequisite Maths.23.

121. Manufacturing Processes Laboratory (1)

Laboratory experiments to illustrate processing techniques studied in I.E. 120. Included are the determination of speeds and feeds used in machining, analysis of forces upon cutting tools, consideration of the effect of coolants, and the determination of horsepower requirements in machine tool operation. Prerequisite or concurrent registration: I.E.120.

122. Production Methods (3)

Analytical study of production methods suitable to high volume manufacture. The engineering approach is used in determining what materials should be used and how they should be processed in manufacturing the desired product. Primary emphasis is placed upon the manufacturing characteristics of materials rather than their chemical or metallurgical qualities. Inspection methods are also studied particularly from the standpoint of precision. Prerequisites: I.E. 120, 121.

123. Production Methods Laboratory (1)

Laboratory exercises to emphasise the production methods studied in I.E. 122. Experiments include the study of engine lathes, horizontal and vertical mills, drill presses, grinders, automatic lathes, mills and screw machine, etc. from the standpoint of power requirements, capacities, finish capabilities, tolerance ranges, etc. Experiments will also cover precision inspection methods. Prerequisite or concurrent registration: I.E.122.

102. Industrial Engineering (3)

An introduction to each phase of industrial engineering with emphasis on the inter-relation of the various functions such as Production Control, Motion and Time Study, Personnel Administration, Quality Control and Plant Layout. Consideration of the way in which each division of an industrial enterprise can best use the information available from other divisions, and how in turn it can be of greatest service to them. This

14. Engineering Graphics I (3)
Engineering drawings, descriptive geometry and graphical solution of problems in mathematics, physics and mechanics are combined in a unique manner to provide a logical sequence and continuity. Applied problems include freehand lettering, graphs from equations and experimental data; orthographic projection of point, line, plans and solid; freehand sketching, pictorial drawings; curved and warped surfaces; surfaces of revolution; dimensioning; applied drafting, specification writing, coplanar and non-coplanar forces; graphical analysis; graphical integration and alignment charts. Six hours of drawing laboratory and one hour lecture per week.

15. Engineering Graphics II (3)
Continuation of E.G.14

E.O. Engineering Orientation (1)
Introduction to college life and the engineering profession. Special topics: college policy, the engineering library, slide rule, how to study, branches of engineering, engineering analysis, report writing and computational procedure.

Second Year

23. Calculus III (4)
Conic sections; parametric equations; vectors; derivatives of logarithmic functions; law of mean; methods of integration.

24. Calculus IV (4)
Solid analytic geometry; partial derivatives; multiple integral; ordinary differential equations.

32. General Physics (4)
The second semester of a three-semester course for all engineering students, covering the field of electricity and magnetism. Lectures, recitations and laboratory. Prerequisite: Physics 31 and Maths.22.

33. General Physics (4)
The third semester of a three-semester course for all engineering students, covering the fields of heat, sound and light. Lectures, recitations and laboratory. Prerequisite: Physics 32.

29. Engineering Mechanics (3)
First principles of dynamics. Newton's laws of motion. 'Dynamic' equilibrium with application of D'Alembert's principle in translation and rotation. Work and energy, impulse and momentum, and introduction to mechanical vibration. Prerequisites: Maths 23 (at least in concurrent registration) and M.: 29.

1a The Structure of the American Economy (3)

Structural and institutional aspects of the modern American economy: resources, impact of technology, major segments of the industrial structure, forms and instruments of business organisation and operation, finance and monetary institutions, labour organisations, mechanisms and location of economic control, the role of government in economic life.

course prepares the Industrial Engineering student for future specialised subjects, enabling him to obtain maximum benefit from following courses in his field, and offers a survey course to others. Prerequisites: Junior standing or consent of instructor.

53. Mechanics of Materials (3)

The fundamental concepts, nature and significance of stress and strain in materials. Theoretical ralationships among load, deformation, stress and strain in members subjected to tension, compression, shear, torsion, bending and combined stress. Prerequisites: M.E.29.

49. Materials Testing Laboratory (1)

Laboratory work on mechanical testing, metallography and their correlation. Three-hour laboratory each week. Pre-requisite: Registration in C.E.53.

45. Principles of Electrical Engineering I. (4)

Course for non-electrical students. Basic theories of electric and magnetic circuits; direct-current circuits; single-phase and polyphase alternating current circuits under balanced conditions: transformers. Three hours recitation, three hours laboratory per week.

46. Principles of Electrical Engineering II (4)

Continuation of E.E.45. The principles, applications and economics of electrical machinery and equipment, characteristics and control of direct-current motors and generators of singlephase and polyphase alternating-current machines. Electronic circuits and apparatus. Pre-requisite: E.E.45. Three hours recitation, three hours laboratory per week.

106. Industrial Plant Visits and Report. (2)

A series of visits to local manufacturing plants and written reports thereon. Practice is given in engineering report preparation. These reports are discussed in the classrooms from the standpoint of content, form, expression and effectiveness. Prerequisite or concurrent registration: I.E.102.

115. Job Evaluation and Wage Incentives (2)

Theory and practice used in the modern industrial plant in determining the proper worth of jobs and positions, policy determination, and practice in the application of standard evaluation techniques used in determining the base rate of pay for a job. The second portion of the course studies historic and current plans used for incentive wage payment and considers the development of plans to meet specific requirements from the standpoint of theory, policy development, and installation. Prerequisite: I.E.102.

128. Engineering Statistics (3)

Application of statistical methods of quality control problems; calculation of averages and measures of dispersions; uses of the normal curve, poisson distribution in sampling; single, double and other sampling techniques; introduction of correlation methods; application of statistical techniques to quality control charts.

Fourth Year

60. Thermodynamics (3)

Fundamentals of engineering thermodynamics. First and second law developments; properties of fluids including gases, vapors, mixtures, elementary psychometrics. Pre-requisite: Maths.28.

70a. Mechanical Engineering Laboratory (1)

The first half of M.E. 70 devoted to thermodynamic experimentation. Prerequisite: M.E.60.

150. Industrial Engineering Seminar (3)

Study and free discussion of many important engineering topics not covered elsewhere in the curriculum, such as engineering ethics, continuation of engineering studies after graduation, and current Industrial Engineering developments. Prerequisites: I.E.102, 115 and 160 or concurrent with I.E.160.

160. Motion and Time Study Engineering (3)

An engineer's course in motion and time study covering the making of stopwatch studies, rating allowance, time standard data, fundamental time data, the uses of process charts, operation analysis, and the principles of motion economy. The techniques of micromotion study are introduced and students analyse film to illustrate advantages of the technique. Prerequisites: I.E.102, 115, and Maths.128, or concurrent with I.W.115 and Maths.128.

170. Industrial Estimating and Costs (2)

Consideration of the inter-related functions of estimating and costing in the modern industrial enterprise, and the development of costs for each product or group of products, up to the level of the manufacturing operating statement. This course also examines the relationship of the cost estimating function to other industrial engineering functions. Prerequisites: I.E. 102 and 122 or permission of instructor.

180. Production Planning and Control (3)

General course on the problems of co-ordinating manufacturing activities in modern plants. Includes selection and classifcation of materials, purchasing, and storing materials, inventory control, determination of plant capacity, selecting economical lot sizes, scheduling, routing, dispatching and production budgets. Prerequisites or concurrent registration: I.E. 122 and 160.

51. Fluid Mechanics and Laboratory (4)

Basic course in fundamentals of fluid mechanics, including compressibility and viscosity; fluid statics and fluid kinetics and dynamics of flow; flow about immersed objects; dimensional analysis and dynamic similarity. Laboratory studies in statics, dynamics and measurements of fluid flow. Three hours of recitation, three hours of laboratory. Prerequisite: Maths. 24 and M.E.31.

175. Engineering Economic Analysis (3)

Deals with economic aspects of engineering decision. The "will it pay" aspect of engineering. Study of comparisons between old and alternative proposed economic plans from an engineering economy viewpoint involving consideration of management, materials, design, machine selection etc. Prerequisite: I.E.170 or permission of instructor.

185. Quality Control (2)

Laboratory investigation of engineering applications of statistical techniques with special reference to quality control work. A prominent feature of the course consists of a term project performed on co-operation with local industry. Pre-requisites: I.E. 102 and Maths. 128.

190. Industrial Plant Design and Layout (3)

Methods and practice of laying out the industrial plant for economical production of goods. Includes selection and arrangement of equipment, location and co-ordination of departments, arrangement of service centres, consideration of factory codes, determination of materials handling and transportation facilities and elementary manufacturing cost of calculations. Prerequisite: I.E. 180.

Technical Electives

165. Advanced Motion and Time Study Engineering (3)

A continuation of selected parts of course I.E.160; operator speed rating, development of standard data, process charts, operation analysis and micromotion study. Students are assigned term projects. Micromotion techniques, including the making of motion pictures, are often used for this project. Prerequisite: I.E. 180.

195. Materials Handling (3)

Analysis of the engineering problems related to the moving and storage of materials in the modern industrial plant. Special emphasis is placed on a study of product to insure selection of manufacturing methods requiring a minimum of material handling. The course includes studies of materials

129. Advanced Engineering Statistics (3)

A course for engineers interested in advanced statistical topics and their use in quality control. Curve-fitting, multiple correlation, significance tests, analysis of variance, chi-square, sequential sampling.

181. Higher Mathematics for Engineers and Scientists. I. (3)

Ordinary differential equations, infinite series. Applications to differential equations. Fourier series and applications and partial differentiation. Introduction to partial differential equations and boundary value problems.

63. Mechanisms.

Analytical and graphical analysis of velocity and acceleration. Transmission of motion by linkages, sliding and pure rolling contacts, cam, gear trains, etc. Miscellaneous mechanisms. Classroom work co-ordinated with drawing room exercises. Prerequisites: M.E. 31.

76. Heat Transfer (2)

The fundamental principles of steady heat transmission by conduction, radiation and convection. Thermal characteristics of materials. Prerequisite: M.E. 60.

101. Elements of Marketing (3)

The course deals with the distribution of goods from producer to consumer and covers such topics as: characteristics of markets for consumer goods and industrial goods; marketing functions and the marketing organisation which performs them; marketing methods and techniques; price policies and costs of marketing.

110. Marketing Principles and Problems (3 and 3)

Basic marketing principles, presented through lecture and textbook, and applied to problems faced by producers, wholesalers, retailers and other middlemen in marketing their products. Prerequisites: Economics I.

101. Elements of Finance. (3)

The course provides a survey of the field of finance for students in the various associated colleges of the University. The course covers financial aspects of starting a business, various types of securities and their uses, working capital requirements and sources, surplus and dividend policies, business failures and reorganisations, and rudiments of commercial banking. No prerequisite.

115. Cost Accounting (3 and 3)

The basic principles of cost accounting are developed and applied to industrial situations. Specific topics include: accounting for material, labour and manufacturing expense; application of costs to operations and to products; preparation of cost statements; analysis of cost information for administrative and control purposes; specific order, process, and standard cost accounting procedures; the application of cost accounting to the functions of distribution; the role of cost accounting in the decisions and policies of management. Prerequisite: Accounting I.

180. Problems in Industrial Relations (3)

Studies are made of various phases of actual union-management negotiations and agreements. Problems of management-labour and governmental industrial relations officers are stressed in this advanced course; the case and discussion methods are used. Prerequisites: Production Management 150 or 151, or permission of the instructor.

101. The Law of Contracts and Sales. (3)

An introductory study of the legal methods is followed by a study of the law of contracts and sales. This course is designed to give the student a basic concept of his legal rights and duties, with emphasis on application to everyday business problems. Required of all business administration students. Prerequisite: Junior standing or permission of instructor.

APPENDIX 8

3 Years University Course leading to an Honours degree in Production Engineering at Manchester University

8.1 CURRICULUM

First Year Honours Course (Common to Mechanical & Production Engineering)

	Hours per week 1st Term	2nd Term	3rd Term
Mathematics	4	4	4
Theory of Machines I	2	2	2
Experimental Methods Laboratory	3	3	-
Materials and Structures I	1	1	1
Applied Thermodynamics I	1	1	1
Mechanics of Fluids I	1	1	1
Machine Design I	1	1	1
Engineering Drawing	3	3	3
Workshop Technology I	3	-	-
Graphics	-	3	3
Electrical Engineering	1	1	1
Electrical Engineering Laboratory	-	3	3
Metallurgy for Engineers I	1	1	1
Physics & Physics Laboratory	3	-	-
Chemistry for Engineers	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{3}{4}$
German	2	2	2
Total Hours	$27\frac{3}{4}$	$27\frac{3}{4}$	$24\frac{3}{4}$
Equivalent Credit Hours	$19\frac{3}{4}$	$19\frac{3}{4}$	$18\frac{3}{4}$
(Assuming 1 lecture hr. = 1 credit hr. 3 lab. hrs = 1 " ")			
Equivalent Study Hours per week (Assuming 1 credit hr. = 3 study hrs)	$59\frac{1}{4}$	$59\frac{1}{4}$	$56\frac{1}{4}$
Hours per 10 week term	592.5	592.5	562.5

Total Study Hours per year = 1747.5

Second Year Honours Course (Common to Mechanical & Production Engineering)

	Hours per week 1st Term	2nd Term	3rd Term
Mathematics	3	3	2
Theory of Machines II	1	1	1
Mechanics of Fluids II	1	1	1
Theory of Machines and Mechanics of Fluids Laboratories	-	3	3
Materials & Structure II	2	2	2
Materials Testing & Structures Labs.	-	3	-
Applied Thermodynamics II	2	1	1
Heat Laboratory	3	3	-
Machine Design II	1	1	1
Engineering Design	6	3	6
Workshop Technology II	-	1	3
Electrical Engineering I	1	1	1
Electrical Engineering II	1	1	1
Electrical Laboratory	3	-	-
Metallurgy for Engineers II	1	1	1
Metallurgical Laboratory	-	-	3
Works Organisation	1	1	1
German	1	1	-
Total Hours	27	27	27
Equivalent Credit Hours	19	19	19
Equivalent Study hours per week	57	57	57
Hours per 10 week term	570	570	570
Total Study Hours per year = 1710			

Third Year Honours Course
Production Engineering

	Hours per week 1st Term	2nd Term	3rd Term
Mathematics	1	1	1
Mathematical Statistics	2	2	2
Theory of Mac hines III	1	1	1
Hydraulic Control	-	½	1
Materials & Structures III	2	1½	1
Servomechanics, Materials Testing, Structures, Electrical, Metrology and Machine Tools Laboratories	6	6	6
Designing for Production, Plant Layout	1	1	1
Specification & Design of Equipment	4	4	4
Power Station Practice	1	1	-
Electrical Measurement & Control	1	1	1
Metrology	1	1	1
Theory of Metal Processing	1	1	1
Commercial Law, Management Principles, Production Control, Labour Efficiency	6	6	6
Total Hours	27	27	26
Equivalent Credit Hours	19	19	18
Equivalent Study hours per week	57	57	54
Hours per 10 week term	570	570	540
Total Study Hours per year = 1680			

Grand Total Study Hours for
Production Engineering Honours Course = 5137.5

Preparatory Course

The normal expectation is that students will have passed at a satisfactory standard at the Advanced level of the G.C.E. in three subjects as follows:

either (i) Mathematics, Physics and Chemistry
or (ii) Mathematics and Theoretical Mechanics together with either Physics or Chemistry.

Candidates for admission who, although qualified for admission to the University are not sufficiently well advanced in their study of the above subjects are required to take the Preparatory Course for the first year, thus making 4 years the minimum duration of attendance at the University.

Curriculum

	Hours per week 1st Term	2nd Term	3rd Term
Mathematics	4	4	4
Mechanics	2	2	2
Mechanics Laboratories	3	3	3
Mechanics Tutorial	1	1	1
Chemistry A or B	2	2	2
Chemical Laboratories	3	3	3
Chemistry Tutorial	-	-	1
Physics	2	2	2
Physics Laboratories	3	3	$2\frac{1}{2}$
Physics Tutorial	1	1	1
Mechanical Engineering	1	1	1
Engineering Drawing	3	3	-
German	2	2	2
Total Hours	27	27	$24\frac{1}{2}$
Equivalent Credit Hours	19	19	19
Equivalent Study hours per week	57	57	57
Hours per 10 week term	570	570	570

Total Study Hours per year = 1710

8.2 DETAILS OF COURSE

Preparatory Course

Mathematics	Algebra. Plane trigonometry. Calculations requiring a familiarity with four-figure tables. Analytical, geometry of the straight line and circle. The elements of the differential and integral calculus.
Mechanics	Uniformly-accelerated motion, projectiles. Motion in a circle and simple harmonic motion. Newton's laws of motion. Force, momentum, energy, work. Simple case of impact. Angular momentum and moment of inertia. Vectors, composition and resolution of vectors. Parallel forces, moments and couples. Laws of friction. Simple machines.
Physics	(a) The properties of matter, the chief phenomena of sound, heat, light, electricity and magnetism, treated in an elementary manner. (b) Practical Physics.
Chemistry	(a) Inorganic Chemistry with special reference to the Non-metals. (b) Introduction to Organic Chemistry <u>or</u> (c) Organic Chemistry. The aliphatic and aromatic hybrocarbons. Methyl and ethyl alcohols. Organic acids. Fats. Soap. Carbohydrates. Solid, liquid and gaseous fuels. Flame and combustion. (d) Practical Chemistry: The qualitative analysis of mixtures which may include inorganic substances, and the more common organic acids and salts. Exercises in simple preparations.
Mechanical Engineering	General introduction to engineering practice. This course is preparatory to courses in Drawing and Design, etc. and covers the following items: engineering materials, manufacturing processes, constructional components, Power plant design and layout, furnaces, compressors, refrigerators, etc.
Engineering Drawing	Principles of orthographic projection. Conic sections; simple intersections and developments. Interpretation of drawings. Sketching of machine parts. Detail drawings and simple assemblies to B.S. 308

First Year

Mathematics	Further differentiation and applications. Elementary rules of convergence of infinite series. Maclaurin's and Taylor's series. Polar co-ordinates. Elementary geometry of conics. Hyperbolic functions. Complex numbers. Partial differentiation. Further standard methods of integration. Numerical integration. Differential equations of the first order. Differential equations of the second order with one variable absent, and with constant co-efficients. The operator D.
Theory of Machines I	Kinematics. Velocity and acceleration diagrams. Kinematics of toothed wheels. Epicyclic gearing and gear trains. Cams. Hooke's joint. Valve diagrams and valve gears. Dynamics of rectilinear and rotational motions. Equivalent dynamical systems. Friction, dry and lubricated. Pivots, bearings and clutches. Brakes and dynamometers. Belt, rope and chain drives. The gyroscope.
Experimental Methods Lab.	Methods of measurement of physical quantities, elementary statistical analysis of experimental results, report writing and general principle of the care and use of instruments. The study and use of the simpler forms of laboratory equipment.
Materials and Structures I	The elementary principles of elasticity applied to bending, shearing and torsion. Stress in thin tubes. The deflection of freely supported beams and plate springs. The physical properties of engineering materials, factor of safety and load factor. Resilence under direct stress, bending and torsion. Geometrical properties of beam sections.
Applied Thermodynamics I	Laws of Thermodynamics and of perfect gases. Properties of matter, etc. Relations between p, v and T for perfect gases and for liquids and their vapours. Other factors of state, including, Entropy. Hypothetical diagrams of state. Theoretical cycles for perfect gases and for vapours. The actual working fluids. Tables and diagrams for steam and other fluids. Reversibility and irreversibility. The regenerative principle and regenerative cycles. Calculations relating to combustion of solid, liquid and gaseous fuels.

Mechanics of Fluids I

Relevant physical properties of fluids, i.e. surface tension, compressibility, volume elasticity and viscosity. Stability of the atmosphere and relation between density and altitude in the isothermal and standard atmosphere. Static pressure on plane surfaces.

Types of fluid motion. Influence of solid boundaries on fluid motion. Bernoulli principle for incompressible flow of a non-viscous fluid. Change of pressure and total head across circular streamlines and application to free and forced vortex motion. General nature of fluid resistance in streamline (or laminar) and turbulent (or sinuous) motion of a viscous fluid.

Application of the Bernoulli principle to steady flow through venturi meters, orifices, notches and weirs and the use of coefficients to correct for the effect of fluid resistance and the contraction of area due to streamline curvature. Principle of dynamical similarity and the dependence of the coefficients on the Reynolds' Number.

Measurement of velocity by use of the Pitot tube.

Losses due to sudden enlargement and contraction of area.

Measurement of pressure and pressure head by various types of manmeter.

Machine Design I

Design of fastenings, power transmission details, pipes, cylinders and other machine parts.

Engineering Drawing

Orthographic projection, intersection and developments, sketching of machine parts. Detail drawings and assemblies conforming to B.S. 308; machined surfaces and leading dimensions. Interpretation of industrial assembly and plant drawings.

Workshop Technology I

Lectures and practical work in the following: principles and use of lathe, planer, shaper and miller. Workshop measurements, B.S.I. system of limits. Marking off. Fitting shop practice.

Graphics

Graphical differentiation and integration. Cam profiles. Velocity and acceleration diagrams for mechanisms. Equilibrium of forces. Vectors. Funicular polygon. Three pinned arch. Graphical and analytical determination of forces in statically determinate frames. Bending moment and shearing force diagrams for dead loads. Simple problems on deflection of beams.

Electrical Engineering	Elementary circuit theorems. Alternating currents; vector treatment, circuit relationships, power, symbolic notation, series and parallel resonance. Measuring instruments, A.C. and D.C.; moving coil, rectifier and thermojunction, moving iron, dynamometer, wattmeters, energy meters, extension of ranges. Magnetic circuit, D.C. machines; windings, armature reaction, commutation, characteristics of motors, speed control and starting, characteristics of generators.
Electrical Laboratory	Elementary applications of bridge and potentiometer circuits. Determination of magnetisation curves of samples. Application of Kirchoff's laws to D.C. networks. Vacuum diode, triode, and mercury vapour diode. Single and double bea, cathode-ray oscillograph.
Metallurgy for Engineers I	The construction and properties of pure metals and alloys. Their response to work and heat-treatment. Pig iron and its properties. The characteristics of the chief steel-making processes. Ingot structures and the working of steel.
Physics	Vibrations of a particle; damped vibrations, forced vibrations and resonance. Wave motion; velocity of sound wavesl reflections and refraction of sound waves; stationary waves; beats; Doppler effect; vibrations in pipes, strings and rods. Light considered as a wave motion. Interference of light; interferometers.
Physics Laboratory	Selected experiments in general physics.
Chemistry for Engineers	An introduction to the chemistry of water supplies, fuels, corrosion, lubrication and other engineering problems.

Second Year

Mathematics	Determinants. Ordinary differential equations (cont.) Laplace transforms. Fourier series. Function of several variables (cont.). Double integrals. Three-dimensional geometry of lines and planes. Introduction to vector analysis.
Theory of Machines II	Torque diagrams, flywheels and governors. Balancing of revolving and reciprocating masses. Free, damped and forced vibrations; torsional vibration and whirling speeds.
Mechanics of Fluids II	Static pressure on curved surfaces. Buoyancy and metacentric height. Dynamical equations for two-dimensional flow. Stream function, vorticity, irrotational motion. Streamline and turbulent flow. Resistance of bodies. Pipe networks, transmission of hydraulic power. Principles of turbine and centrifugal pump operation.
Theory of Machines Lab.	Determination of moments of inertia of connecting rod and flywheel by compound pendulum and bifilar suspension methods. Balancing rotating masses and use of crankshaft balancing machine. Experiments on simple slide valve and Walschaerts valve gear. Determination of governor characteristics. Epicyclic gearing. Whirling of shafts.
Mechanics of Fluids Lab.	Stability of a floating body. Experimental demonstration of Bernoulli principle. Flow through orifices and venturi tube. Use of pitot tube. Discharge over weirs. Impact of jets on surfaces. Measurement of viscosity. Pipe resistance
Materials and Structures II	Method of tension coefficients for resolving forces in space frames. Deflection of frames by graphical and analytical methods. Hinged arches. The effect of moving loads for simple beams. The use of influence lines. Unsymmetrical bending. Momental circle and ellipse. Columns and struts under axial and eccentric loading and with initial crookedness. The bases for various empirical strut formulae. Reinforced concrete beams and columns. The strength of thick cylinders. More advanced work on the deflection of beams, beams on three or more supports. Methods for dealing with changes in level of support and of beam section. Distribution of shear stress in beams and the deflection due to shear. Principal stresses, the circle of stress. Applications to combined bending and torsion and to the theory of earth pressure. Derivation of theories of failure, with applications. Discussion of failure arising in practice. Helical springs.

Materials Testing and Structure Laboratories	Properties of materials in tension, torsion and shear. Hardness and impact tests. Deflection of leaf and coil springs. Experimental determination of elastic stress distributions. Deflection of beams, struts, simple framed structures, three pinned arch, continuous beams, rolling loads.
Applied Thermo-dynamics II	Description of i.c. engine cycles. Comparison of actual and theoretical cycles and efficiencies. Combustion characteristics of fuels and factors influencing combustion. Types of combustion chamber. Theory of gas turbine cycles and consideration of practicable arrangements. Theory of refrigerators and heat pumps. Working fluids. Description of plant and calculation of performance. General consideration of reciprocating, centrifugal and axial flow compressors. Calculations in relation to Rankine cycle, with steam charts and tables. Nozzle flow and design of steam nozzles. Blading diagrams for steam turbines. Descriptive work on steam turbines. Introduction to heat transmission. Condenser types and performance. Simple feed water heating systems. Steam raising.
Heat Laboratory	Calorimetry. Calibration and use of pressure gauges, indicators and orifices. Gas analysis. Construction of T- and H- charts for water vapour. Loading tests on steam, gas and oil engines. Mixture strength experiments in closed vessel, gas engine and petrol engine. Injector and ejector tests. Air compressor test. Heat account for steam turbine. Heat transfer rate in experimental condenser and heat losses from lagged pipes.
Machine Design II	Design of cast and welded frames and brackets, thin shells, thick cylinders, flat plates, shafting, bearings, cranks, connecting rods, power screw, flywheels, gearing, tolerancing.
Engineering Design	Major machine parts, or complete machines will be designed and the requisite drawings prepared.
Workshop Technology II	More advanced work on the following machines: Universal miller plain miller, capstan, turret and automatic lathes including planning and time calculations. Also broaching machines, plain and universal grinders, centreless grinders. Selection of best machines and methods for different classes of work.

Electrical Engineering I	Transformers, principles, equivalent circuits and vector diagrams, regulation and efficiency, auto-transformers, impedance matching. Polyphase circuits; 3 phase connections, power and measurement. Induction motors; characteristics, speed control starting, testing. Switchgear, fuses, circuit breakers. Illumination, units, laws, measurements and standards.
Electrical Engineering II	Thermionic emission; characteristics of vacuum diode; triode, pen tode; gas-filled diode and triode, mercury arc rectifier, C.R. tubes, photo-electric cells. Electronic circuits; types and design of amplifiers, oscillators, modulation and demodulation. Measurements; A.C. Bridges, measurements of frequency discriminating circuits, filters. Electromechanical analogies.
Electrical Laboratories	Test on D.C. machines. Experiments on alternating currents, transformers, induction motors.
Metallurgy for Engineers II	The construction, structure, properties and response to heat-treatment of selected non-ferrous alloys, carbon steels, alloy steels and cast iron.
Metallurgical Laboratory	The microscopic examination of steels and cast irons.
Works Organisation	<u>Work Measurement and Wages Systems</u>. Motion Study; principles and technique. Time study; definition aims, organisation, personnel and technique. Incentives; time and piece systems, bonus schemes, other financial and non-financial incentives to output and efficiency. Job evaluation; bases of wage systems, job analysis and evaluation techniques, use of job specifications. <u>Costing and Estimating</u>. Elements of cost accounting. Costing systems. Overheads and their application. Cost control. Cost recovery. Tendering; procedure and methods quality and quantity factors, treatment of overheads in estimating. <u>General Works Organisation</u>. The functions of management. Levels of authority and responsibility. Principles of organisation. Relations in organisation - direct, functional and 'staff'. Formulation of policy and its interpretation. The human element - leadership and morale.

Third Year

Mathematics	A selection will be made from the following: Solution of differential equations in series. Partial differential equations of mathematical physics. Spherical harmonics. Bessel functions. Theory of vibrations. Theory of Elasticity. Operational methods. Complex integration. Conformal transformations. Numerical methods. Calculus of variations. Elliptic functions.
Mathematical Statistics	Statistical data. Frequence distributions and measures of location and scale. Elements of probability. Theoretical distributions: Binomial, Poisson, Normal. Quality control. Sampling inspection: single, double and sequential sampling schemes.
Theory of Machines III	More advanced problems on kinematics and dynamics. Coriolis acceleration; balancing and balancing machines. Gyroscopic stabilisation. Torsional vibrations of multi-rotor and geared systems. Vibration dampers and vibration stresses. Whirling speeds.
Hydraulic Control	Hydraulic control. Hydraulic, electrical pneumatic drives. Hydraulic circuit components and layout. Control circuits. Open and closed loop systems. Transient and harmonic analysis, stability. Non-linear effects.
Materials and Structures III	A selection will be made from the following: Laterally and eccentrically loaded struts and ties. The bending of curved beams. Stresses in statically indeterminate frames and in stiff jointed frames. Strength of thick cylinders including shrink fits and rotating discs. Deflection and stress in loaded flat plates. The torsion of non-circular sections. Discussion of creep, fatigue, plasticity, stress concentration and allied subjects. Bending beyond the elastic limit.
Designing for Production, Plant Layout	Design of assemblies and detail parts. Sequence of production operations. Material preparation. Standardisation of speeds and feeds, preferred numbers. Jigs and fixtures. Machining quality, accuracy, surface finish. Inspection technique and equipment. Power consumption of machine tools. Power distribution, material flow, production procedure, supervision. Industrial lighting. Accuracy of machine tools. Tool life and tool maintenance. Standardisation of parts.

Specification and Design of Special Equipment	Jigs and fixtures. Special purpose machine tools. Discussion of typical successful designs.
Power Station Practice	Coal and ash handling plant. Methods of improving steam-cycle efficiency. Fuel characteristics. Firing systems, grates, pulverised fuel and oil. Furnace types and arrangement of heating surface in boilers. Superheaters, economisers and air heaters. Superheat control. Dust extraction. Fan control. Condensers and feed water heating systems. Cooling towers. Power station efficiency, load factor and availability. Instrumentation and automatic control of boiler plant. Special exhuast arrangements in modern turbines. Throttle and nozzle cutout forms of governing.
Electrical Measurements and Control	Transients in electrical networks. Fourier analysis of waveforms. Open and closed loop control systems, stability, transient and harmonic analysis, dynamic response of d.c. machines, netadyne. Electro-mechanical measurements, transducers for measuring displacement, velocity, acceleration and strain, associated measuring circuits, calibration.
Metrology	Limits and fits. Standards of length and angle, comparators. Measurement of gauges, profiles and threads. Interferometry. Flatness, straightness and alignment. Surface finish.
Theory of Metal Processing	Casting. Forming. Cutting. Welding.
Management Principles, Production Control Labour Efficiency	Principles. Production Control. Preparation of Production. Progressing the job through the production processes. Final costing as a check on the efficiency of the production department. Selection and efficiency of labour. Human relations.
Commercial Law	Law of Contract - agency; Partnership; Companies, chartered, public and private; conversion from one type of undertaking to another. Holding Companies. Capital - nature and purposes served by Debentures. Bank and other loans; shares, statutory meetings. Liquidation. Inland and Foreign Bills, cheques, promissory notes. Insurance - life, fire, marine. Casualty. Income-tax and sur-tax.

APPENDIX 9

SUMMARY OF CURRICULA OF

Course XV-A, Business and Engineering Admin. at M.I.T.
Industrial Engineering Course at Syracuse University
Production Engineering Honours Course at Manchester University.

9.1 Table showing hours devoted to each subject.

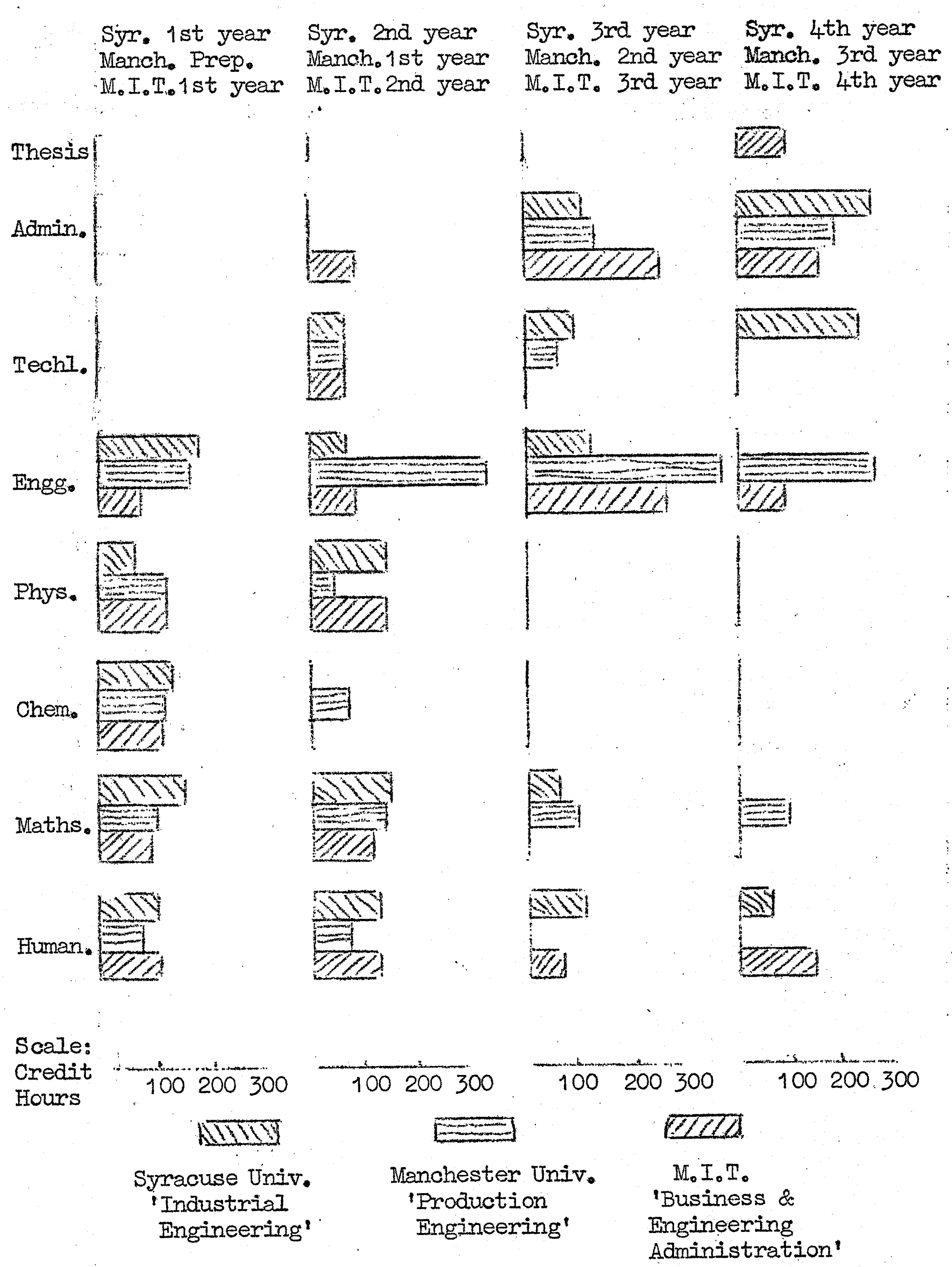
Subject	M.I.T. Year	M.I.T. Total Hours	SYRACUSE Year	SYRACUSE Total Hours	MANCHESTER Year	MANCHESTER Total Hours
General Chemistry	1	120	1	128	Prep.	120
Physics	1	120	1	64	Prep.	120
English (Manchester German)	1	90	1	96	Prep.	60
Mathematics	1	90	1	154	Prep.	120
Engineering Drawing	1	60	1	96	Prep.	20
Mechanics			2	96	Prep.	120
Mechanical Engineering					Prep.	30
Applied Mechanics	2	90	3	64	1	30
Machine Tools	2	30	3	32	1,2	70
Physics	2	120	2	128	1	30
Industrial Management	2	90				
Humanities	2	90	2	96	See German	
Mathematics	2	90	2	128	1	120
Theory of Machines					1	60
Experimental Methods Lab.					1	20
Applied Thermodynamics	3	90	4	64	1	30
Mechanics of Fluids	3	45	4	64	1	30
Machine Design					1	30
Engineering Drawing					1	30
Graphics					1	20
Electrical Engineering	4	60	3	128	1	50
Metallurgy for Engineers	3	60			1,2	70
Chemistry for Engineers					1	53
German					1	60
Economic Principles	3	45				
Accounting	3	45				
Marketing	3	45				

Total Hours calculated as Credit Hours per week x academic weeks in year. i.e. 1 lecture hour = 1 credit hour. 3 laboratory hours = 1 credit hour.

Subject	M.I.T. Year	M.I.T. Total Hours	SYRACUSE Year	SYRACUSE Total Hours	MANCHESTER Year	MANCHESTER Total Hours
Personnel Admin.	3	45			See Labour Efficiency	
Finance	3	45				
Production Management	3	45	3	80	2	30
Humanities	3	45	3	96		
Manufacturing Processes			3	48	3	50
Production Methods			3	40	See Design for Production	
Wages Incentives			3	32	See Production Management	
Engineering Statistics			3	48	See Maths. Stats.	
Mathematics					2	80
Theory of Machines	4	45			2	40
Mechanics of Fluids					2	40
Materials & Structures					2	70
Thermodynamics					2	60
Machine Design					2	30
Engineering Design					2	50
German					2	20
Humanities	4	90				
Professional Elective	4	90				
Hum. or Prof. Elective	4	90	4	48		
Industrial Electronics	4	45			2	70
Thesis	4	90				
Ind. Eng. Seminar			4	48		
Motion & Time Study			4	48	See Production Management	
Ind. Estimating			4	32		
Prod. Planning & Control			4	48	See Production Control	
Technical Elective			4	96		
Eng. Econ. Analysis			4	48		
Quality Control			4	32	See Maths. Stats.	
Ind. Plant Layout			4	48	See Design for Production	
Mathematics					3	30
Maths. Statistics					3	60
Theory of Machines					3	30
Hydraulic Control					3	15
Materials & Structures					3	55
Design for Production					3	30
Specification & Design of Equipt.					3	30
Power Station Practice					3	20
Electrical Measurement & Control					3	50
Metrology					3	50
Commercial Law Management Principles Production Control Labour Efficiency					3	180

APPENDIX 9.2

CHART OF COURSE CONTENT



APPENDIX 10

4-Years Technical College Sandwich Course leading to a Higher National Diploma in Production Engineering.

BIRMINGHAM COLLEGE OF TECHNOLOGY

Entry Qualifications Students who have passed G.C.E. examinations at Ordinary Level in Mathematics, Physics, English and two other subjects and wo have also completed an S.2 year with high marks, may be selected by the College to enter the Intermediate year of the Diploma Course.

Curriculum Intermediate Year	Total Hours
Mathematics	142
Physics (Heat, light, sound)	116
Chemistry	65
Principles of Electricity	65
Applied Mechanics	65
Engineering Drawing	26
Economic and Human Relations	78
	557
First Year Final	
Mathematics	142
Physics	65
Chemistry and Metallurgy	52
Principles of Electricity	65
Applied Mechanics	65
Applied Heat and Mechanics of Fluids	65
Engineering Drawing	26
Economic and Human Relations	78
	558
Second Year Final	
Mathematics	130
Principles of Materials & Mechanics of Machines	52
Strength of Materials & Mechanics of Machines	65
Mechanics of Fluids and Applied Thermodynamics	65
Metallurgy and Materials	52
Engineering Drawing	26
Technology of Production	65
Economic and Human Relations	78
	533
Third Year Final	
Mathematics	65
Strength of Materials	39
Mechanics of Machines and Vibrations	52
Mechanics of Fluids	26
Metallurgy	52
Electrical Engineering and Electronics	52
Design & Application of Production Equipment	26
Measurement and Control of Quality	52
Work Study	39
Factory Organisation and Costing	52
Economic and Human Relations	78
Statistics	52
	585
Fourth Year Final	
Mechanics of Machines and Vibrations	52
Production Design Analysis & Economics of Production	26
Production Control and Supply Organisation	26
Management Principles and Practice	52
Industrial Psychology	52
Mechanics of Metal Processing	52
Measurement and Control of Quality	26
Plant Layout and Material Handling	52
Design and Application of Production Equipment	26
Project Work	130
	494

Summary of Subject and Teaching Hours

		Int.	1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	Total
Mathematics	(Mathematics	142	142	130	65	-	531
	(Statistics	-	-	-	52	-	
Physics	Physics	116	65	-	-	-	181
Chemistry	Chemistry	65	52	-	-	-	117
Engineering	(Engg. Drg.	26	26	26	-	-	78
	(App. Mechanics	65	65	52	52	52	286
	(App. Electronics	65	65	-	52	-	182
	(App. Thermodynamics) (Mechanics of Fluids)	-	65	65	26	-	156
	(Strength of Materials) (Mechanics of Machines)	-	-	65	52	-	117
	(Metallurgy & Materials	-	-	52	52	-	104
	(Mechanics of Metal (Processing	-	-	-	-	52	52
Technical	(Technology of Prod.	-	-	65	-	-	65
	(Design & App. of (Prod. Equipment	-	-	-	26	26	52
	(Measurement and Cont. (of Quality	-	-	-	52	26	78
	(Work Study	-	-	-	39	-	39
	(Production Design (Analysis & Economics (of Production	-	-	-	-	26	26
	(Plant Layout & (Material Handling	-	-	-	-	52	52
Administrative	(Factory Organisation (and Costing	-	-	-	-	52	52
	(Production Control & (Supply Organisation	-	-	-	-	52	52
	(Management Principles (and Practice	-	-	-	-	52	52
Social Humanistic	(Economic & Human (Relations	78	78	78	78	-	312
	(Industrial (Psychology	-	-	-	-	52	52
Project		-	-	-	-	130	130
						TOTAL HOURS	2766

APPENDIX 11

Part time Day Course leading to the Higher National Certificate in Production Engineering.

Birmingham College of Technology

In order to reach a uniform standard of entry for comparison purposes, it is assumed that students have passed courses S1 and S2.

	Actual Hours	Credit Hours	Total Credit Hours
Course S3			
Workshop Technology III	$2\frac{1}{4}$	$1\frac{1}{2}$	54
Applied Mechanics III	$2\frac{1}{2}$	$1\frac{1}{2}$	54
Mathematics III	$2\frac{1}{4}$	$2\frac{1}{4}$	81
Applied Electricity I	$2\frac{1}{2}$	$1\frac{1}{2}$	54
			243
Course A1			
Metallurgy	$2\frac{1}{4}$	$1\frac{1}{2}$	54
Applied Mechanics IV	$2\frac{1}{2}$	$1\frac{1}{2}$	54
Machine Tools	$2\frac{1}{4}$	$1\frac{1}{2}$	54
Mathematics IV	$2\frac{1}{4}$	$2\frac{1}{4}$	81
Applied Electricity	$2\frac{1}{2}$	$1\frac{1}{2}$	54
			297
Course A2			
Metrology	$2\frac{1}{4}$	$1\frac{1}{2}$	54
	$2\frac{1}{4}$	$1\frac{1}{2}$	54
	$2\frac{1}{2}$	$1\frac{1}{2}$	54
			162

Summary of subjects by categories.

Mathematics	162
Engineering	270
Technology	270
Grand Total...	702

APPENDIX 12

Evening Course leading to Higher National Certificate in Production Engineering

A similar standard of entry is assumed as in Appendix 11 and Courses S1 and S2 are considered as prerequisites.

Third Year	Actual Hours	Credit Hours	Total Credit Hours
Workshop Technology	$2\frac{1}{4}$	$1\frac{1}{2}$	54
Mathematics	$2\frac{1}{4}$	$2\frac{1}{4}$	81
Applied Mechanics	$2\frac{1}{4}$	$1\frac{1}{2}$	54
			189
Fourth Year			
Applied Mechanics	$2\frac{1}{2}$	$1\frac{1}{2}$	54
Machine Tools	$2\frac{1}{4}$	$1\frac{1}{2}$	54
Metallurgy	$2\frac{1}{2}$	$1\frac{1}{2}$	54
			162
Fifth Year			
Jig and Tool Design	$2\frac{1}{4}$	$1\frac{1}{2}$	54
Machine Tools	$2\frac{1}{4}$	$1\frac{1}{2}$	54
Metrology	$2\frac{1}{4}$	$1\frac{1}{2}$	54
			162

Summary of Subjects by Categories

Mathematics	81
Engineering	162
Technology	270
GRAND TOTAL	513

APPENDIX 13

Bridgeport Engineering Institute

Course 1 - MECHANICAL ENGINEERING.

First Term	Second Term	Third Term
	FIRST YEAR	
Slide Rule (M1) Algebra (M2) Chemistry C1a) Eng. Draw. (D1a)	Algebra (M3) Chemistry (C1b) Eng. Draw. (D1b)	Algebra (M4) App. Geometry (M5) Chemistry Lab. (C1 L)
	SECOND YEAR	
Trig. and Logs. (M6) Physics (B1) Metallurgy (C2)	Calculus (M7) Physics (B2) Metallurgy (C3)	Physics Lab. (B1, 2L) Descriptive Geom. (D2)
	THIRD YEAR	
Calculus (M8) Physics (B3) Statics (J1)	Calculus (M9) Physics (B4) Dynamics (J2)	Physics Lab. (B3,4L) Electrical Lab. 1 (L1) Summer Reading (R2)
	FOURTH YEAR	
Kinematics (J3) Heat Engineering (T1) English (G3) Spec. and Reports (G4)	Strength of Materials (J4) Heat Engineering (T2) Economics (G2)	Testing Materials Lab. (L4) Metal Processing
	FIFTH YEAR	
Strength of Materials (J5) Electrical Eng.(E1) Principles of Ind. Org. (H1)	Machine Design (D5) Electrical Eng. (E2) Fluid Mechanics (B8)	

Summary of Hours by categories for three final years

Mathematics	90
Physics	100
Engineering	540
Humanities	95
Administration	45
Technical	25
Total...	895

DESCRIPTION OF SUBJECTS

Subjects are arranged in the alphabetical order of their designating symbols. The first of the numbers following a subject (45-3) indicates the total class hours, the second number the semester or credit hours. Class hours are exclusive of examinations and preparation of outside assignments. Regular 45-hour subjects are given 3 hours per week for one term; 90-hour subjects 3 hours per week for two terms; others as indicated.

B1 PHYSICS (Prerequisite M4 with M6 concurrently) 45-3

Mechanics: Newton's Laws of Motion, accelerated linear and angular motion; simple harmonic motion; composition, resolution and equilibrium of forces; work, power energy; friction; simple machines.

Textbook: Weber, White and Manning - College Physics.

B2 PHYSICS (Prerequisite B1) 45-3

Fluids: Hydrostatics; fluids in motion.

Heat: Temperature and its measurements; kinetic theory of gases, thermal properties of liquids, solids and gases; conduction of heat; change of state.

Sound: Wave motion, production and transmission; reflection, refraction; absorption and interference; audition and voice sounds.

Light: Illumination and photometry; reflection and refraction, lenses, spectra; interference and diffraction.

Textbook: Weber, White and Manning - College Physics.

B3 PHYSICS (Prerequisite M7) 45-3

Electricity and Magnetism: Definitions of electrical units; computation of resistance; wire computations; power and energy; Ohm's and Kirchoff's laws; magnetic fields and magnetic circuits.

Textbook: Timbie - Elements of Electricity.

B4 PHYSICS (Prerequisite B3) 45-3

Electricity and Magnetism: Electro-chemical action, Principles of D.C. motors and generators; inductance; capacitance; introduction to Alternating Currents.

Textbook: Timbie - Elements of Electricity.

B1, 2L PHYSICS LABORATORY (Prerequisite B2) 38-$\frac{1}{2}$
(15 - $2\frac{1}{2}$ hr. periods)

Experiments illustrating friction; force parallelograms; mechanics of motion; heat and calorimetry; wave motion; sound and light phenomena; practice in making careful observation and conclusive reports.

B3, 4L PHYSICS LABORATORY (Prerequisite B4) (10 - $2\frac{1}{2}$ hr. periods) 25-$\frac{1}{2}$

Experiments illustrating electricity and magnetism; instruments; electromagnetic action; bridges; potentiometer; inductance and capacitance; practice in making careful observation and conclusive reports.

B8 FLUID MECHANICS (Prerequisite B2, J2) 45-3

A study of the behaviour and affects of incompressible fluids at rest and in motion, and an introduction to compressible fluids, hydrostatics; Bernoulli's theorem and the principle of similarity; an analysis of flow through orifices, nozzles, and pipes; energy relationships as applied to pipe lines, pumps, and turbines; acceleration of fluid masses; fluid dynamics - the momentum theorem, jet reaction.
Textbook: Binder - Fluid Mechanics.

C1 CHEMISTRY 90-6

The fundamental idea of matter and energy; the properties of gasses, liquids and solids; molecular weights; equations; atomic structure; classification of the elements; ionic reaction; the chemistry of the metals and non-metals with particular reference to their industrial application; and an insight into the chemistry of the carbon compounds.
Textbook: Babor - Basic College Chemistry.

C1L CHEMISTRY LABORATORY (8 - $2\frac{1}{2}$ hr. periods) 20-$\frac{1}{2}$

Experiments designed to teach laboratory technique, to demonstrate the application of fundamental chemical laws, and to familiarize students with chemical compounds and test methods in common industrial use.

C2 METALLURGY (Prerequisite C1) 45-3

The principles of physical metallurgy, including structure of metals, crystallization, phase diagrams, eutectics, changes occurring in metals during hot or cold working; laboratory methods, pyrometry, metallography, microstructure and its relation to the physical properties.
Textbook: Clarke & Varney - Physical Metallurgy for Engineers.

C3 METALLURGY (Prerequisite C2) 45-3

Iron, steel and ferrous alloys and their uses; heat treating processes, tempering, carburizing and nitriding; fatigue and creep of metals, and the commercial methods of detecting flaws and non-uniformity of materials; properties and uses of aluminium, copper, magnesium, zinc, nickel, lead and their alloys.
Textbook: Clarke & Varney - Physical Metallurgy for Engineers.

D1 ENGINEERING DRAWING 90-4

The selection and use of instruments and drawing equipment; shop sketching, perspective, third angle orthographic projection; shop drawings of machine parts, assemblies, and tools; tolerances, finishes, and miscellaneous machine details such as bolts, screws, keys and pins; standard drafting room practice and symbols as used in structural, electrical and piping drawings. Outside preparation is required.

Textbook: French - Engineering Drawing.

D2 DESCRIPTIVE GEOMETRY (Prerequisite D1) 30-2
(12 - $2\frac{1}{2}$ hr. periods)

An analysis of the theory of orthographic projection, including auxiliary and oblique views; problems involving points, lines and planes in space and the revolution of points, lines and planes about axes; practical applications in solving difficult drafting problems. Outside preparation is required.

Textbook: Warner - Applied Descriptive Geometry.

D5 MACHINE DESIGN (Prerequisite J5) 45-3

Methods of approach to problems of machine design; application of principles of kinematics and dynamics to machine design; proportioning of machine elements to withstand forces applied to them; safe working stresses; stress concentration; design of gears based on dynamic loading, thermal stresses and deformation in machine elements; comparison of standard specifications and strength of materials.

Textbook: Faires - Design of Machine Elements.

E1, 2 ELECTRICAL ENGINEERING (Prerequisites B4; M8) 90-6

The application of fundamental physical laws to the determination of dynamo electrical machine characteristics; the development of the laws of alternating current circuits by vector representation and analysis; the principles of operation of alternating current machines and distribution circuits.

Textbook: Cook & Carr - Elements of Electrical Engineering.

E5 ELECTRICAL MACHINERY (Prerequisite E1, 2) 45-3

Application of theory to the study of synchronous generators, motors, converters, including alternators in parallel operation, motor application problems and control apparatus. Theory and operation of mercury vapor rectifiers.

Textbook: Puchstein & Lloyd - Alternating Current Machines

E6 ELECTRICAL MACHINERY (Prerequisite E1, 2) 45-3

Application of theory to the study of transformers, induction motors, series motors and repulsion motors including application problems and control apparatus.

Textbook: Puchstein & Lloyd - Alternating Current Machines.

E7, 8 FUNDAMENTALS OF ELECTRONICS (Prerequisite E1, 2) 90-6

The application and study of the theory of electronics including capacitance, inductance, electron emission, characteristics of electron tubes, rectifier circuits, amplifier circuits, oscillators, control circuits, photoelectric tubes and cathode-ray tubes. In each case particular emphasis is placed on industrial applications.
Textbook: Richter - Fundamentals of Industrial Electronic Circuits.

G2 ECONOMICS 45-3

Wealth, income and property; elementary accounting; the organisation of production; demand supply, and price; money and banking; trade and transportation; risk and insurance; taxation and public finance, the distribution of wealth and income.
Textbook: Umbreit, Hunt & Kinter - Fundamentals of Economics.

G3 ENGLISH (17-1½ hr. periods) 25-1½

The principles involved in writing concise and accurate business correspondence.
Textbook: Stevenson, Spicer and Ames - English in Business and Engineering.

G4 SPECIFICATIONS AND REPORTS (Prerequisite completion of 3rd year) (15-1½ hr. periods) 23-1½

The place and importance of specifications in industry and construction; the development, use and limitations of specifications; national, professional and standard specifications.

The evaluation of data, their sources and uses in preparing reports; practice in the organisation of material and the preparation of concise and accurate reports.
Textbook: Nelson - Writing the Technical Report.

H1 PRINCIPLES OF INDUSTRIAL ORGANISATION 45-3

Development in industry, capital and financial organisation; industrial management organisation, operating the enterprise, production planning, material control, routing and scheduling, quality control, methods engineering, plant layout; industrial relations principles, personnel management, training, safety, employee relations; building and administering the wage structure, accounting and cost control, expense and cost, pricing the product; sales and sales promotion.
Textbook: Kimball & Kimball - Principles of Industrial Organisation.

J1 STATICS (Prerequisites B1 and M7 with M8 concurrently) 45-3

Review of fundamental concepts, vector representation, free bodies, conditions for equilibrium; forces and simple stresses in two and three dimensional frames, trusses and machines; friction. Centers of gravity; cables; analysis and solutions by mathematical and graphical methods.
Textbook: Singer - Engineering Mechanics.

J2 DYNAMICS (Prerequisites J1 and M8) 45-3

Moments and products of inertia; dynamical forces, momentum and energy of systems in translation and rotation; theory of kinematics of particles and linkages under rectilinear and curvilinear motion; mathematical and graphical methods; review of work, energy and power; momentum and impact; dynamic balance, critical speeds and vibration; elementary problems in vibration and rigid bodies in motion.
Textbook: Singer - Engineering Mechanics.

J3 KINEMATICS (Prerequisites D1 and J2) 45-3

Graphic applications of principles of kinematics to basic machine mechanisms; graphic and algebraic analysis of velocities and accelerations in transmission of motion by direct contact, linkage, gears, sliding block mechanisms, cams and belts.
Textbooks: Schwamb, Merrill & James - Elements of Mechanisms.
Singer - Engineering Mechanics.

J4 STRENGTH OF MATERIALS (Prerequisite M9, J2) 45-3

Physical properties of materials; basic stress-strain relations in two dimensions; thin walled cylinders and spheres; riveted and welded joints; torsion; shafting, coupling and related applications; theory of bending, including normal and shearing stresses, elastic curves; eccentric loading, combined axial and transverse loading, column theory.
Textbook: Singer - Strength of Materials

J5 STRENGTH OF MATERIALS (Prerequisite J4) 45-3

Continuation of J4. Deflection of determinate and indeterminate beams by integration area moment and superposition; continuous beams, three moment theorem; combined stress relationships. Mohr's circle of stress, theories of failure, unsymmetrical loading and bending; stress concentration factors and strain-energy relationships; curved flexural members; stresses in plates and thick walled cylinders; torsion of rectangular bars and other sections.
Textbook: Singer - Strength of Materials.

L1 ELECTRICAL LABORATORY (Prerequisite B4) 30-$\frac{1}{2}$
(10-3 hr. periods)

The course precedes the study of Electrical Engineering Experiments to acquaint the student with methods of connecting and operating commercial motors and controllers of determining electrical measurements, and of determining input, output and efficiency.

L2 ELECTRICAL LABORATORY (Prerequisites E1, 2 and L1) (10-3 hr. periods) 30-$\frac{1}{2}$

A more advanced course including additional tests of direct current motors and generators to determine speed, voltage and efficiency characteristics, and tests to demonstrate the fundamental relations of alternating current circuits.

L3 ELECTRICAL LABORATORY (Prerequisite L2) (10-3 hr. periods) 30-$\frac{1}{2}$

This course extends the work of Electrical Laboratory II to polyphase circuits and a.c. machinery, supplementing the theoretical work of the previous year and leading up to the course in Electrical Machinery.

L4 TESTING MATERIALS LABORATORY (Prerequisite J4) (16-2$\frac{1}{2}$ hr. periods) 40-2

Investigation of properties of engineering materials utilising facilities of industrial testing and research laboratories; strength, hardness and microscopic structure of ferrous and non-ferrous materials; characteristics of woods; concrete and aggregates; techniques of data analysis and report writing.

Textbook: Davis, Troxell & Wiskocil - Testing and Inspection of Engineering Materials.

L5 ELECTRONICS LABORATORY (Prerequisites E1, 2) 30-$\frac{1}{2}$

This laboratory course precedes the study of Fundamentals of Electronics. Experiments to acquaint the student with the elementary theories of electron emission and electron tubes; and the basic principles of electronic apparatus and circuits prior to their theoretical work in Electronics.

M1 SLIDE RULE (10-1 hr. periods)

The theory and use of the slide rule, using simple arithmetical and and mensuration problems as a basis of instruction; intended to develop confidence and accuracy in the use of the slide rule for subsequent engineering work.

M2, 3 ALGEBRA 90-6

Notation, operations, factoring, fractions; simple and fractional equations, involution and evolution; theory of exponents; radical expressions and imaginaries; radical quadratic, and simultaneous quadratic equations; fundamentals of graphs and charts, and their application.

Textbook: Hawkes, Luby and Touton - First Year Algebra.

M4 ADVANCED ALGEBRA (Prerequisite M2, 3) (16-1$\frac{1}{2}$ hr. periods) 24-1$\frac{1}{2}$

Ratio, proportion, variation, progression; variables and limits, series; the binomial theorem; permutations and combinations; properties of determinants; complex numbers; theory of equations including synthetic division.

Textbook: Rouse - College Algebra.

M5 APPLIED GEOMETRY (16-1½ hr. periods) 24-1½

A review of the basic theorems of plane geometry; surfaces and volumes of solids; the solution of right triangles; applications of geometry to engineering problems.
Textbook: Smith, Reeve and Morss - Text & Tests in Plane Geometry; Supplementary notes and problems.

M6 TRIGONOMETRY AND LOGARITHMS (Prerequisite M4) 45-3

Functions of the angles; theory and use of common and natural logarithms; use of trigonometric tables - trigonometric equations, trigonometric identities, solution of right and oblique triangles; practical applications of trigonometry.
Textbook: Crathorne & Lyttle - Plane Trigonometry.

M7 CALCULUS (Prerequisite M6) 45-3

Differentiation and integration of algebraic functions; derivatives and differentials; maxima and minima; applications to some problems in geometry and mechanics, such as the determination of velocity; acceleration, areas, volumes, and pressures; the analytic gemometry of the straight line and conic sections, the plotting of curves in rectangular co-ordinates.
Textbook: Woods & Bailey - Elementary Calculus.

M8 CALCULUS (Prerequisite M7) 45-3

Differentiation, integration and graphical representation of trigonometric, inverse trigonometric, logarithmic and exponential functions with applications to simple problems in geometry and mechnaics such as related velocities, empirical equations, simple harmonic motion and curvature; analysis of polar co-ordinates and series.
Textbook: Woods & Bailey - Elementary Calculus.

M9 CALCULUS (Prerequisite M8) 45-3

Partial differentiation; integration of functions of one variable including use of tables; definite integrals, also double and triple integration, as applied to areas and lengths of plane curves, volumes of solids, work, pressure, centres of gravity and moments of inertia.
Textbook: Woods & Bailey - Elementary Calculus.

R2 SUMMER READING

Selected home reading adjusted to the needs of the individual student, designed to increase the student's appreciation of the value and necessity of cultural as well as technical preparation for his career as an engineer and leader of men. The work is carried on through the co-operation of the Public Library.

S3 METAL PROCESSING (12-2½ hr. periods) 30-2

The use of machine tools; the casting and hot and cold rolling of metals; forging; drawing; brazing; welding. Presented as a course of lectures supplemented by slides and motion pictures and by shop visitations.

Textbook: Clapp & Clark - Engineering Materials & Processes.

T1 HEAT ENGINEERING (Prerequisite B2 and M8) 45-3

Elementary thermodynamics; the laws and properties of gases and vapours; use of steam tables and charts; flow of fluids; principles of refrigeration and combustion.

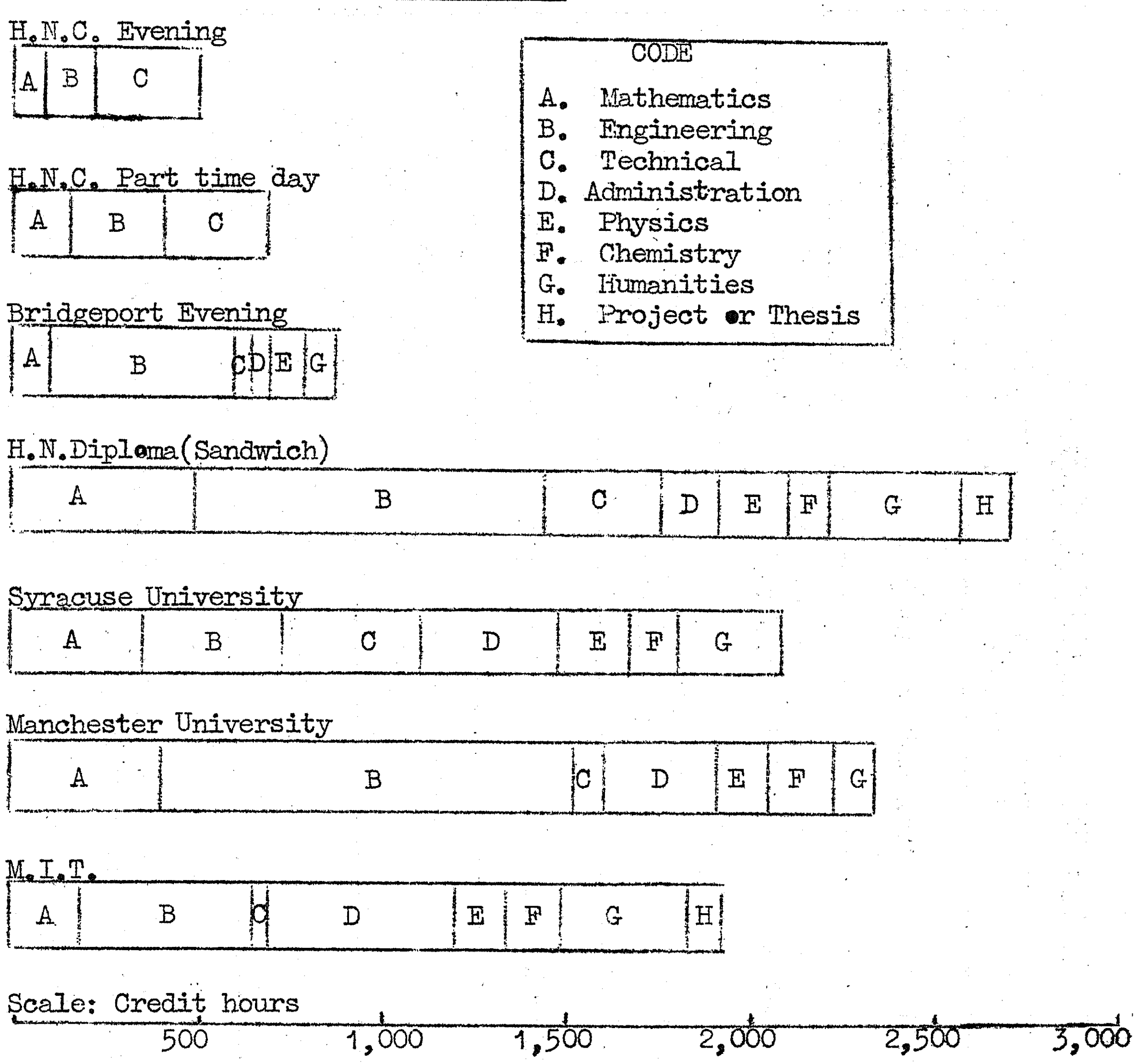
Textbook: Severs & Degler - Steam, Air & Gas Power.

T2 HEAT ENGINEERING (Prerequisite T1) 45-3

Steam power plant engineering including fuels, types of plants, boilers, fuel handling and burning equipment, air heaters, fans, chimneys, steam engines and turbines, condensers, pumps and feed water heaters; internal combustion engines and their application; problems of heating and the principles of air conditioning.

Textbook: Severns & Degler - Steam, Air & Gas Power.

APPENDIX 14



GRAPHICAL SUMMARY OF THE CONTENT OF THE FOLLOWING COURSES:

H.N.C. Part time day and evening - 'Production Engineering'

H.N. Diploma (Sandwich) - 'Production Engineering'

Manchester University Honours Course 'Production Engineering'

Bridgeport Engineering Institute (U.S.A.) - 'Mechanical Engineering'

Syracuse University Course - 'Industrial Engineering'

Massachusetts Institute of Technology - 'Business and engineering administration'

APPENDIX 15 COLLEGE OF TECHNOLOGY BIRMINGHAM

SUBJECTS OF STUDY FOR THE DIPLOMA IN INDUSTRIAL ADMINISTRATION

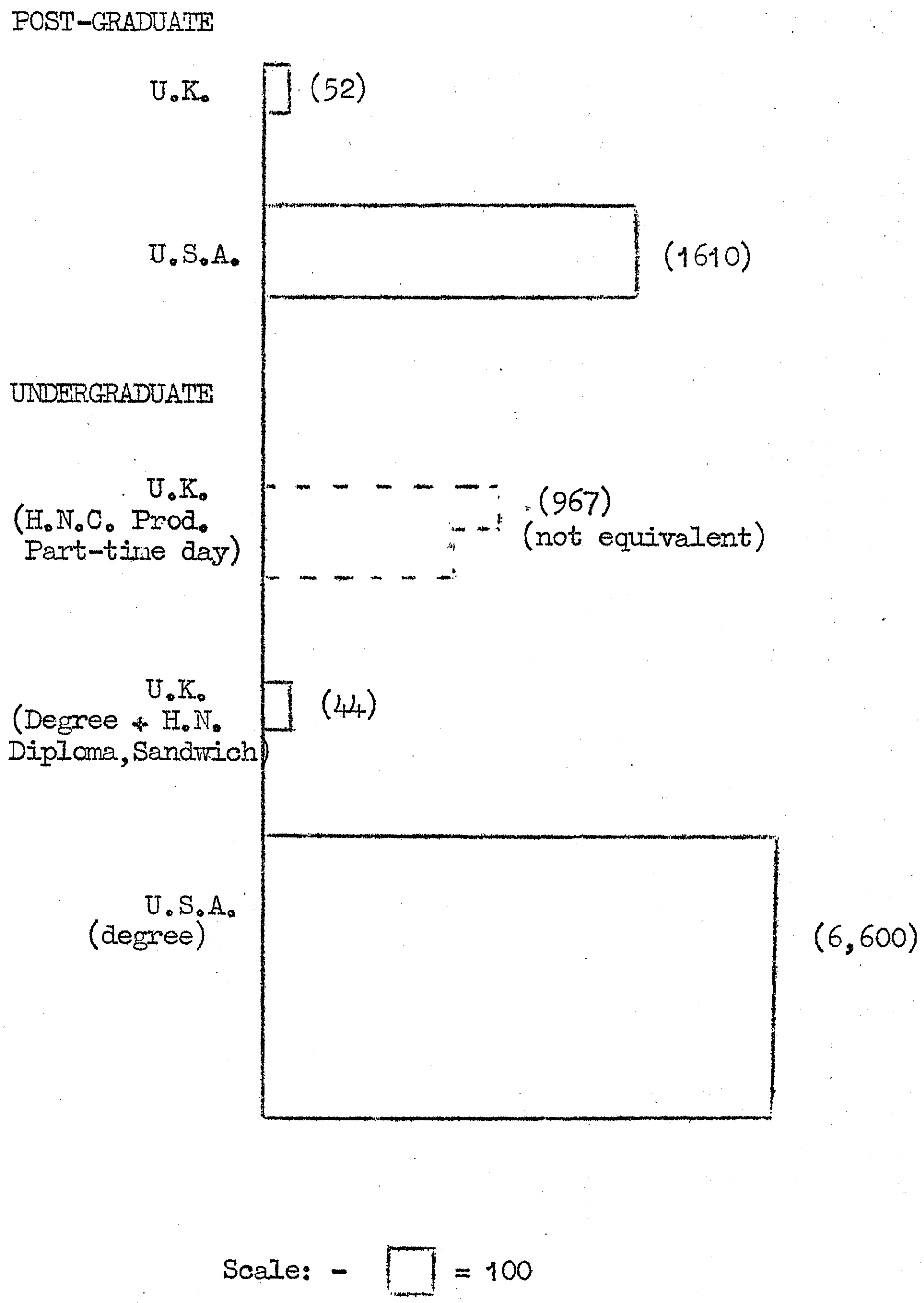
Stage I	Stage II	Stage III	Stage IV
Organisation of Industry	Industrial Relations	Personnel Administration	Management Practice
Factory Organisation	Production Control and Purchasing Organisation	Office Organisation and Mechanisation	Structure of Industry
Work Study	Statistical Method	Economics of an Industrial Community	Budgetary and Higher Control
Factory Costing and Estimating	Industrial Accounting	Industrial Finance, I.	Industrial Finance, II.
Product Design and Development	Industrial Law	Market Research and Business Forecasting	Sales Organisation, Publicity and Advertising
English Usage	Psychology of Supervision	Industrial Psychology	Management Principles

The Sequence of study - from Stage I to Stage IV - has been planned for those having a technical or scientific training.

Students working for the Diploma must closely follow this scheme.

APPENDIX 16

Comparison of number of students in U.S.A. and U.K. taking courses in Industrial Engineering or equivalent.



APPENDIX 17

University of Birmingham
One Year Post-Graduate Course of Studies.

The general scope of the main subjects is as follows:-

1. PRINCIPLES OF ENGINEERING PRODUCTION AND MANAGEMENT

(a) The Economic Analysis of Industrial Projects:

The measurement and control of the factors affecting production costs and productivity.

The efficient and economic production of manufactured products and the co-ordination of the research, engineering, planning and control functions of management to this end.

The economics and planning of job, batch, and flow production; the measurement of the effectiveness of the manufacturing unit.

Budgeting for production, research and the development of new products.

(b) General Principles of Business Organisation:

Organisation plans; the functions and relationships of production and other departments.

Business structure; the formation and control of limited liability and trust companies.

Operational research, statistics and controls.

Market research and sales organisation.

Personnel administration; selection and training.

(c) Production Planning and Control:

Process planning, machine loading and utilisation.

Progress control, stores control, control of quality and material utilisation.

(d) Factory and Plant Layout:

Factors affecting the selection of factory sites; design of factories, stores and auxiliary services.

Shop layout for job, batch and flow production; machine arrangements; conveyors and mechanical handling. Transportation.

II WORK STUDY

Work Study as a management function.

Analysis of the flow of work; plant layout and materials handling.

Multiple operation analysis; labour and machine utilisation.

Principles of motion economy. Methods development and work place layout. Operator training.

Work measurement. Performance rating. Proportions of rest and work. Allowances for non-standard conditions. Levelling techniques. Policy allowances. Synthetic times. Motion time standards. Patterns of output.

Principles of wages payment. Comparative study of incentive schemes.

Principles and methods of Job Evaluation and Merit Rating.

III APPLIED STATISTICS

Frequency distributions; Probability; Statistical analysis of production variables; Tests of Significance; Correlation; Sampling procedures; Control charts; Design of Experiments; Analysis of variance; Operational research.

IV INDUSTRIAL MEASUREMENTS

Product Design; Production Standards; Standardisation.

Metrology; Limits and fits, tolerances; measurement of flat surfaces; angles etc.; surface finish measurement.

Tests of Machine Tool Performance.

Mechanical, optical and electronic methods of inspection, process and production control; Servo-systems.

ADDITIONAL SUBJECTS

In addition to the above subjects, students will be required to attend lectures in Physiology, Occupational Health, Experimental Psychology and in the Use of Speech. Lectures are also provided by arrangement with the Faculty of Commerce and Social Science in Industrial Law, Cost Accounting, and Industrial Relations.

APPENDIX 18

One Year Post Graduate Course on Industrial Engineering.

Syllabus of Course

1. PRODUCTION ENGINEERING

Machine Tool efficiency
Economics of production processes
Process planning, estimating
Machine loading, machine utilisation
Factory layout
Fundamentals of machinability and formability
Jig and Tool design and associated economics
Metrology

2. ENGINEERING ECONOMICS

Economic Analysis of manufacturing situations
Economic Batch sizes
Economic Yield analysis
Minimum cost point
Kelvin's Law

3. WORK STUDY

Method Study - Principle of Motion Economy.
Operation process and flow process charts, flow diagrams, multi-activity charts, film analysis
Developing and installing new method

Work Measurement - Rating and normalising
Computation of allowances
Determination of work values
Preparation and use of synthetics

Incentives

Job Evaluation

4. BUSINESS ADMINISTRATION & ECONOMICS

Financial Accounting
Analysis of Income and Expenditure
Company statements and returns
Capital structure of Limited Companies
Sources and application of funds
Planning working capital
Forecasting and the Business Cycle

Industrial Accounting
Budgetary Control, Standard Costing, Marginal costing
Costing statistics, Comparative Cost Analysis
Analysis of variances and their relation to control and policy formation
Costs as a guide on policy decisions

Business Control Methods

Materials Control
Production Control
Mechanical aids and systems
Visual charting and recording

Economic Analysis of Industry & Commerce

Types of business organisation
Optimum size of undertaking
Money credit and banking
Capital market
National income analysis

5. ORGANISATION & MANAGEMENT

Analysis of Administrative and Executive responsibilities
Control and Direction of Human Activities
Establishment of Standards of Performance
Training within Industry
Personnel Management
Scientific Techniques applied to Management Studies

6. INDUSTRIAL STATISTICS & OPERATIONS RESEARCH

Problems of dealing with numerical information
Application of probability to decisions
Sampling schemes in theory and practice
Quality control
Application of probability theory to 'queueing' and congestion problems
Market research and allied techniques
Introduction to problems of estimating economic relationships numerically
Linear programming and activity analysis
Planning in highly complex organisations
Learning curves, labour build-up problems
Long-term production forecasting

7. SUPPORTING SUBJECTS

Supplementary to the main subjects outlined are courses in Industrial Law, Industrial Psychology, Report Writing and Oral Expression.

8. PROJECT

Co-ordinating the whole structure of the course is a 'Project' involving the flotation of a company, its financing, organisation, forecasting of

labour requirements and build-up, preparation of production programme, design of factory, machine selection and machine loading, design of tools, factory layout, design of accounting and control systems and presentation of final balance sheet.

APPENDIX 19. Section I.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

General Chemistry 5.01

Lecture, Recitation and Laboratory Outline

		Lecture and ecitation	H. & P.[1]	L. & H.[2]	B.L. & P.[3]	Problem Sheets
I	1	Introduction	I		1,2	1
	2	Weight Relationships	II			
II	3	Chemical Equations and Gas Laws	III		1,2	2
	4	Vapor Pressure - Dalton's Law	III			
III	5	Atomic and Molecular Weights	IV		3	3
	6	Thermochemistry	VII			
IV	7	Conc. of Solutions; Titration (noble gases and H2)	VI	I,II	6	4
	8	F.W. Method; Atomic Structure	V,XVI			5
V	9	Periodic Table	XVII		7	6
	10	Electrolytic Dissociation	VIII			
VI	11	Electrolytic Dissociation	VIII		21,22	7, 8
	12	Balancing Chemical Eqns.	IX, XV			9
VII	13	Oxygen (Nomenclature)	X	III	23	
	14	Alkali Metals - Rate of Reaction	XI	IV		
VIII	15	Effect of Conc. on Equilibrium	XII		24	10, 11
	16	Mass-Action Law	XIII			
IX	17	Mass-Action Law	XIII		25	
	18	Mass-Action Law	XIII			
X	19	Mass-Action Law	XIII		27	
	20	Carbonic Acid Equilibria	XXI			
XI	21	Carbonic Acid Equilibria			28	12, 13
	22	Oxidation and Reduction Reactions	XV			
XII	23	Voltaic Cells	XV		29	
	24	Voltaic Cells	XV			
XIII	25	Voltaic Cells	XV		30	14
	26	Alkaline Earth Metals		V		
XIV	27	Alkaline Earth Metals		V	31	
	28	Structure of Molecules				
XV	29	Aluminium		VI		16
	30	Boron		VI		

1 - Hildebrand & Powell 'Principles of Chemistry') combined
2 - Latimer & Hildebrand 'Reference Book of Inorganic Chemistry')
3 - Bray, Latimer & Powell 'A Course in General Chemistry'

APPENDIX 19, Section 2.

Problem Sheet - General Chemistry

Atomic Structure and the Periodic Table

1. On the physical scale of atomic weights (O^{16}=16) the atomic weights and relative abundance of the isotopes of hydrogen and oxygen are:

H^1	1.008123	99.98%
H^2	2.014708	0.02
O^{16}	16.	99.757
O^{17}	17.00450	0.039
O^{18}	18.0049	0.204

Calculate the atomic weight of hydrogen on the chemical scale

(O (ave.) = 16). Ans. 1.0080

2. Calcium has an atomic number of 20 and an atomic weight of 40. How many neutrons and protons are in the nucleus? How many electrons are in the atom and how are they grouped?

3. Show that the Pauli Exclusion Principle limits the maximum number of electrons in an s sub-shell to 2, a p sub-shell to 6, a d sub-shell to 10, and and f sub-shell to 14. See H. p.289.

4. Show that in the first and second periods of the Periodic Table there can be only 8 elements each, in the third and fourth periods only 18 elements each, and in the fifth period 32.

5. Write the kernel symbols for:

(a) Na
(b) Na^+
(c) Cl^-
(d) NaCl
(e) Cl_2
(f) $S^=$
(g) $SO_4^=$
(h) $SO_2^=$
(i) H_2SO_4

6. (a) How does the ionization potential for the first electron of the gaseous atom change in a period starting with an alkali metal and going to the succeeding noble gas? How does it change with atomic no.within a group?

(b) How does the electron affinity change with atomic no. within a group?

7. How does the stability of hydrogen compounds of the non-metallic elements vary with position of the element in a period and with the position in a group?

8. List the maximum positive and maximum negative oxidation states for the elements in each group of the periodic systems. How are these correlated with electron structure of the atoms?

9. (a) How does the basic character of the oxides of a group vary with increasing atomic number?
(b) How does the basic character of the oxides of an element vary with the oxidation number?
(c) How are the above variations explained by atomic structure?

APPENDIX 19, Section 3.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

General Chemistry 5.02

Lecture, Recitation and Laboratory Outline

		Lecture & Recitation	L. &. H.	H.	B. & L.	Problem Sheets
I	1	The Halogens	X		41	1
	2	The Halogens	X			
II	3	Copper	VII		42,44	2
	4	Silver	VII			
III	5	Zinc, Cadmium	VIII		43,45	3
	6	Mercury	VIII			
IV	7	Sulphur (Selenium, Tellerium)	XII		61	4
	8	Sulphur	XII			
V	9	Nitrogen	XI	XIV	61	5
	10	Nitrogen: Ox.Red. Reactions	XI			
VI	11	P, As, Sb, Bi	XI		47	6
	12	P, As, Sb, Bi	XI			
VII	13	Iron	XIX		46	7
	14	Iron	XIX			
VIII	15	Cobalt, Nickel	XIX		62	8
	16	Manganese	XVIII			
IX	17	Manganese	XVIII		62,48	8
	18	Chromium	XVII			9
X	19	Chromium	XVII		49,51	9
	20	Tin	XV			10
XI	21	Lead	XV		50	
	22	Silicon	XIV	XXIII		11
XII	23	Silicon. Acid-Base Systems	XIV	XXII	63	
	24	Carbon	XIII	XVIII		12
XIII	25	Carbon	XIII	XVIII	63	
	26	Carbon	XIII	XVIII		
XIV	27	Radio Chemistry	XXII	XVI	52	13
	28	Radio Chemistry	XXII	XVI		
XV	29	Review				
	30	Review				

APPENDIX 19, Section 4.

Radio Chemistry

1. Calculate the energy in Mev and ergs corresponding to the nuclear reaction:

$$_{3}Li^{7} + {}_{1}H^{1} = 2\ {}_{2}He^{4} - \quad E$$

where $_{3}Li^{7}$ = 7.01822, $_{1}H^{1}$ = 1.0812, and $_{2}He^{4}$ = 4.00390

1 amu = 9 x 10^{22} ergs/g.-atom   932 Mev/particle.

Ans. 1.7 x 10^{19} erg, 17.3 Mev.

2. How does the atomic mass number and atomic number of a nucleus change in the following disintegrations:

(a) emission
(b) emission
(c) emission
(d) positron emission
(e) neutron captured, gamma ray emitted
(f) deutron captured, gamma ray emitted
(g) capture of a K electron

3. (a) The nucleus $_{14}Si^{31}$ is a emitter with a half life of 170 minutes. What will be the total number of electrons emitted in 170 minutes from 1 microgram of pure $_{14}Si^{31}$? Use 6.02 x 10^{23} for the Avogadro number.
(b) What will be the total number of electrons emitted in 340 minutes from one microgram of pure $_{14}Si^{31}$?

Ans. (a) 1 x 10^{16}; (b) 1.5 x 10^{16}

4. Identify X in the following nuclear reactions and give its atomic number and atomic mass number:

(a) $_{7}Ni^{14} + {}_{2}He^{4} = {}_{8}O^{17} + X$
(b) $_{94}Pu^{239} + {}_{2}He^{4} = {}_{96}Cm^{240} + 3X$
(c) $_{9}F^{19} + {}_{1}H^{1} = {}_{8}O^{16} + X$
(d) $_{92}U^{235} = {}_{93}Np^{239} + X$
(e) $_{92}U^{235} + {}_{o}n^{1} = {}_{35}Br^{81} + X + 2\,{}_{o}n^{1}$
(f) $_{11}Na^{22} = X + {}_{1}^{o}$

5. (a) A sample of radioactive potassium K^{43} (half life 18 min.) has an initial activity of 1600 counts per minute. What activity will be observed after 72 minutes?

(b) Calculate the half life of a radioactive substance whose activity falls from 1000 counts per minute to 125 counts per minute in 24 hours.

Ans. (a) 100; (b) 8 hours.

6. One gram of pure Ra^{226} undergoes 3.7 x 10^{10} disintegration per second. Calculate and the half life of Ra^{226}.

Ans. = 1.4 x 10^{-11} sec.$^{-1}$; $t_{\frac{1}{2}}$ = 1560 years.

APPENDIX 19, Section 5

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

8.02 PHYSICS

LECTURE TOPICS			Text, Chap.
Feb.	9	Kepler's law, Cavendish experiment, Law of gravitation	15
	11	The gravitational field	15
	16	Simple harmonic motion	14
	18	Simple and physical pendulum, center of percussion	14
	23	Damped and forced oscillations, resonance	14
	25	Coupled oscillations, traveling waves on string, kinematics	26
March	2	Traveling waves on strings, dynamics, differential equation and Fourier analysis	26
	4	Reflection of waves on string. Standing waves	27
	9	Standing waves, resonance.	27
	11	Hydrostatics	16
	16	Temperature, ideal gas thermometer	18
	18	Heat, Calorimitry	19
	23	The first Law of Thermodynamics. The thermal and caloric equations of state of matter	
	25	The thermal equation of state of ideal gases, p-V diagram, isothermal, isobaric and isochoric changes	22
April	6	The caloric equation of state of ideal gases, free and isothermal expansion	22
	8	C_v, C_p and adiabetic changes	22
	13	The Carnot Cycle	24
	15	The absolute temperature and the Second Law of Thermodynamics	24
	20	Kinetic Theory of gases	25
	22	The law of Equipartition of energy	25
	27	Entropy and Probability	
	29	Brownian motion, viscosity of gases	25
May	4	The thermal equation of state of solids. Elasticity and thermal expansion	13
	6	The caloric equation of state of solids, Dulong-Pettit's law	
	11	Lattice Theory of solids	
	13	The binding forces between atoms	
	18	The liquid state. Van der Waals equation for real gases	23
	20	The Clausius Clapeyron equation	23
	25	Mechanics of liquids.	

APPENDIX 19, Section 6.

Program in M11 Calculus

Textbook: Thomas - 'Calculus and Analytic Geometry', 2nd edition.

Date	Lesson	Article	Topic
9-24	1	1-1,2,3	Intro.Coord.Dir.Line seg
9-27	2	1-4	Slope of line
9-29	3	1-5	Eq. of line
10-1	4	1-6	Funcs. graphs
10-4	5	1-7; 8	Slope, deriv.
10-6	6	1-8	Derivative
October 8 Examination at 9 a.m. covering Lessons 1-6			
10-11	7	1-9	Velocity, rate
10-13	8	1-10	Props. of limits
10-15	9	2-1	Deriv. of poly.
10-18	10	2-2	Der. Rat. funcs.
10-20	11	2-3	Implicit diff.
10-22	12	2-4; 5	Increm. chain rule
10-25	13	2-6; 7	Differentials
10-27	14	2-8	Continuity
October 29 Examination at 9 a.m. covering lessons 7-14			
11-1	15	3-1; 2	Sign $\frac{dy}{dx}$; rel. rates
11-3	16	3-2	Related rates
11-5	17	3-3; 4	Sign d^2y/dx^2, curves
11-8	18	3-5;6	Max. and min.
11-10	19	3-5; 6	Max. and Min.
11-12	20	3-7; 8	Rolle's the., mean val. th.
11-15	21	4-1; 2	Indef. integral
11-17	22		Review selected by Instructor
November 19 Examination at 9 a.m. covering lessons 15-22			
11-22	23	4-3	Applications
11-24	24	4-4	Sines, Cosines
11-29	25	4-4	Sines, cosines
12-1	26		Review selected by instructor
December 3 Examination at 9 a.m. covering lessons 23-26			
12-6	27	4-5	Area as integral
12-8	28	4-6	Area as limit
12-10	29	4-7	Definite integral
12-13	30	4-7	Definite integral
12-15	31	4-8; 9	Area between curves
12-17	32	4-10	Distance
1-3	33	4-11	Volume
1-5	34	4-11	Volume
January 7 examination at 4 p.m. covering lessons 27-33			
1-10	35	4-13	Arc length
1-12	35	4-13	Surface area of Rev.
1-14	37	5-1	Mom. ctr. mass
1-17	38		Review selected by instructor
1-19	39		Review selected by instructor

APPENDIX 19, Section 7

Program in M12 Calculus

Textbook: Thomas - 'Calculus and Analytic Geometry', 2nd edition.

Date	Lesson	Article	Topic
2-12	1	6-1	Curves and Eqs.
2-15	2	6-2, 3	Tangent and normal
2-17	3	6-3	Distance
2-19	4	6-4	Sec. degree curves
2-24	5	6-5	Circle
2-26	6	6-6	Parabola
3-1	7	6-7	Ellipse
3-3	8	6-8, 10	Hyperbola, conic sec.
Examination March 5 at 9 a.m. covering lessons 1-8			
3-8	9	7-1; 2	Polar coord.
3-10	10	7-1; 2	Polar coord.
3-12	11	7-3	Polar coord.
3-15	12	7-4	Angle, Arc length
3-17	13	7-5	Area
Examination March 19 at 4 p.m. covering lessons 9-13			
3-22	14	8-1	Trig. functions3-24
3-24	15	8-2; 3	Inverse Trig. functions
3-26	16	8-3	Inverse trig. functions
4-5	17	8-4; 5	Log functions
4-7	18	8-5,6,7	Log functions
4-9	19	8-8	Exponential Fns.
4-12	20	8-9	Exponentia l Fns.
4-14	21	9-1; 2	Hyperbolic Fns.
4-16	22	9-3; 4	Derivatives, Integrals
4-21	23	9-5	Inverse hyper. fns.
Examination April 23 at 9 a.m. covering lessons 14-23			
4-26	24	10-1	Integration formulas
4-28	25	10-2	Powers of Trig. Fns.
4-30	26	10-2; 3	Powers of Trig. Fns.
5-3	27	10-4	$a^2 - u^2$ etc.
5-5	28	10-5	$ax^2 + bx + c$
Examination May 7 at 9 a.m. covering lessons 24-28			
5-10	29	10-6	Partial fractions
5-12	30	10-7	Integrations by parts
5-14	31	10-9	Other substitutions
5-17	32	11-1	Parametric equations
5-19	33	11-2	Parametric equations
Examination May 21 at 9 a.m. covering lessons 29-33			
5-24	34	11-3	Vector components i, j

APPENDIX 19, Section 8

D13 - Graphical Processes

Schedule

Lesson	Subject
1.	Registration. Discussion of purposes of the course, materials required. Lecture on the philosophy of graphics.
2.	Graphic Arithmetic. a. Basic principles of addition, subtraction, multiplication and division. b. Addition and multiplication of functions.
3.	Scales and scale construction. a. Mechanics of scale construction. b. Scale equation and modulus. c. Construction of slide rules.
4.	Graphic solutions of equations. a. Linear simultaneous equations. b. Quadratic roots and quadratic and linear combinations. c. Cubics by approximations.
5.	Elementary alignment charts and monograms. a. Construction and uses of each.
6.	Conics a. Definition by section of cone. b. Analytic definition and relation to (a) c. Construction by analytic definition d. Constructinn by other means (not projective) including approximations.
7. and 8.	Projective Geometry. a. Cross ratio b. Photogrammetry c. Conics by projection d. Conic lofting e. Duality
9. and 10.	Graphic Calculus. a. Basic integration and differentiation. b. Integration of closed areas. c. Product integration. d. Centroids and moments. Marks (modified).

APPENDIX 19, Section 8 (continued)

Lesson	Subject
11 and 12	Empirical Curves. a. Linear functions. Methods of approximation of line by eye and method of least squares. b. Uses of logarithmic papers for power and exponential functions. c. Power functions with additive constant.
13.	Vectors. a. Arithmetic of vectors. b. Polar coordinate paper. c. Static problems and relative movement problems.
14.	Periodic Curves. a. Generation by polar diagram. b. Analytic considerations - amplitude, period etc. c. Combinations by addition.
15.	Harmonic Analysis a. Breakdown of periodic curves.
16.	Curve Fitting. a. Determination of general types b. Grapho-analytical methods of fitting (finite differences). c. Construction of empirical data.

APPENDIX 19, Section 9.

INSTRUCTORS' OUTLINE FOR 2.001

Applied Mechanics I

M = Meriam, 'Mechanics - Part I: Statics'

T = Timoshenko and MacC., 'Elements of Strength of Materials

Class Meeting	Topic	Paragraphs
1	Intro., Forces and moments	11 - 15 M
2	Resultants	16 - 17 M
3	Space Systems	19 M
4	Equilibrium	20 - 22 M
5	"	"
6	Equilibrium in space	24 - 26 M
7	Centroids	33 - 38 M
8	Hydrostatics	40 - 41 M
9	Buoyancy	42 - 43 M
10	Friction	50 - 51 M
11	Wedges Screws	52 - 53 M
12	Belt friction	56 M
13	Trusses (joints)	27 - 29 M
14	" (sections)	30 M
15	Frames Machines	32 M
16	" "	
17	Work	58 - 62 M
18	Energy	63 - 66 M
19	Comparison of methods for frames, machines	
20	Stress, strain	1 - 6 T
21	Thermal stress	7 - 8 T
22	Hoop stress	9, 17 T
23	Castigliano (tension only)	97 T
24	Shear, bending moment	44 - 45 M 30 - 31 T
25	" " "	46 M, 32 T
26	Differential relations	47 - 49 M
27	Bending stress	33 - 35 T
28	Shear stress	41 - 43 T
29	Appications	
30	"	44 T
31	Built up beams	47 T
32	Composite beams	74 T
33	Reinforced concrete	75 T
34	Torsion	79 T
35	"	80 T
36	Plane Stress	18, 20, 23 T
37	Mohr's circle	21, 22 T
38	Combined stress	83 - 85 T

APPENDIX 19, Section 10.

2.002 Applied Mechanics II

Instructors' Schedule for Fall Term

Texts: M = Meriam, Mechanics, Part II: Dynamics
T = Timoshenko and MacCullough, Strength of Materials

Class Meeting	Subject Material	Reading
1	Review of Statics and Stresses	-
2	" " "	-
3	Stress at a Point, Strength Theories	18-23, 107 83-85T
4	" "	"
5	" "	"
6	" "	"
7	" "	"
8	" "	"
9	" "	"
10	Strain at a point	24-29 T
11	" "	"
12	" "	"
13	Deflections	49-53, 64-69T Class Notes
14	"	"
15	"	"
16	"	"
17	"	"
18	"	"
19	Kinematics	68-81M
20	"	"
21	"	"
22	"	"
23	"	"
24	"	"
25	Kinetics - Translation	82-93 M
26	" "	"
27	" "	"
28	" "	"
29	" "	"
30	Kinetics - Rotation	94-96, A1-A12M
31	" "	"
32	" "	"
33	" "	"
34	" "	"
35	Kinetics - Plane Motion	97 M
36	" "	"
37	" "	"
38	" "	"
39	" "	"

APPENDIX 19, Section 11.

MASSACUSETTS INSTITUTE OF TECHNOLOGY

Assignments PHYSICS 8.03

Week of:		Monday Lectures	Tuesday Recitations	Wednesday Lectures	Thurs/ Saturday Recitations
Sept	20	Registration	Secs 1.1,1.2 Ch. 1	Ch 1:Coul.law. Resistance meters	Ch 1:
Sept	27	Sec 2.1 Elec.field	Ch. 2	Sec. 2.2 Gauss's Law	Ch. 2
Oct	4	Sec 2.3 Potential	Ch.2	Secs 2.4 and 2.5 to p.43	Ch. 2
Oct	11	Secs 2.5,2.6	Holiday	3.1 Nuclear Structure	Ch. 2
"	18	Quiz on Chaps 1 + 2	Ch. 3	Secs 3.2,3.3, Electrons + atom structure	Ch. 3
"	25	Sec.3.4 Gas discharges	Ch. 3	Secs 3.5,3.6 Vac. tubes Beams	Ch.3
Nov.	1	Sec.4.1 Polarization + breakdown	Ch. 4	Secs 4.2, 4.3 En.in dielectrics	Ch.4
"	8	Secs 4.4,4.5 Conduct. + semi-conductors	Ch. 4	D. Sec.5.1.D.C. Circuits	Ch. 5 (Thurs., Nov.11) Holiday)
"	15	Secs 5.2,5.3	Ch. 5	Sec. 5.4 Vac. tube Applications	Ch. 5 or review
"	22	Quiz Chaps 3,4,5	Ch. 5	Secs 6.1,6.2	Holiday
"	29	Secs 6.3,6.4 Mag.fields	Ch. 6	Sec 6.5	Ch. 6
Dec	6	Sec 6.6 Magnetization	Ch. 6	Sec 7.1 Induced emf.	Ch. 7
"	13	Secs 7.2,7.3	Ch. 7	Secs 7.4,7.5	Ch. 7
			CHRISTMAS	HOLIDAY	
Jan	3	Sec 7.6	Ch. 7	Secs 8.1,8.2	Ch. 8
"	10	Quiz Chaps 6 + 7	Review	8.3 Resonance	Ch. 8
"	17	Sec 8.4	Review		

<u>Text:</u> Bitter, 'Currents, Fields and Particles" (1954)

APPENDIX 19, Section 12

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Physics 8.04 Problems

Section 13.5

1. The angular deviation of a third-order spectrum line produced by a transmission grating 2 cm. wide with 110 lines per mm is $11^{\circ}11'$. What is the wavelength of the light? If another line can barely be resolved, in this order, from the one just mentioned, what is the difference between the wavelengths?
   Ans. 5.88×10^{-5} cm. 0.89×10^{-8} cm.

2. Parallel light falls normally on a plane reflection grating with 1000 lines per mm. In what direction is the first-order spectrum of sodium light reflected from the grating? What is the answer if the angle of incidence is 30°?

3. An idealized grating with alternate perfectly clear and perfectly opaque spaces gives a spectrum in which all the even orders are

4. In an idealized grating of clear and opaque spaces the second-order line is half as intense as the first. Calling the intensity of the first-order line 1, find the intensities of the line in the third and fourth orders.
   Ans. 1/9; 0.

5. If yellow light is observed at an angle of 36 degrees with a grating ruled with 5000 grooves per cm, what is the wavelength of the light?

6. The limits of the visible spectrum are nearly 4,000 to 7,000 A. Find the angular breadth of the first-order visible spectrum formed by a plane grating with 12,000 lines per inch.

   Does the violet of the third-order visible spectrum overlap the red in the second-order spectrum? If so, by how much (approximately)?

7. Light containing two wave-lengths of 5,000 and 5,200 A is normally incident on a plane diffractiom grating having a grating spacing of 10^{-3}cm. If a 2-meter lens is used to focus the spectrum on a screne, find the distance between these two lines (in centimeters) on the screen:
   a) for the first-order spectrum
   b) for the third-order spectrum.

Section 13.6

1. Two narrow slits 0.14 mm apart are illuminated by a flame giving sodium light. What must be the diameter of a lens 6 meters away to resolve the images of the two slits?

APPENDIX 19, Section 13

PROGRAM IN M 21

Lesson	Article	Topic
1	11-1;2	Parametric equations
2	11-3;4	Vector components i, j. Diff. of vectors
3	11-5;6	Tan. norm. vect. curves
4	11-7	Vel. and accel.
5	11-8	Polar coordinates
6	13-1;2	Space coord. vectors
7	13-3;4	Scalar product, vector product
8	13-5	Lines and planes
9	13-6	Prod. of 3 or more vec.
10	13-7	Diff. vectors
11	13-8	Space curves
12	13-9;10	Cylinders; quadratic sur.
13	13-10	Surfaces
14	14-1;2	Fns. of 2 var; par. der.
15	14-3;4	Tang. norm; approx w
16	14-5;6	Direc. deriv. gradient
17	14-7;8	Chain rule; tot. diff.
18	14-9;10	Max-min.
19	14-11;12	Max-min; higher deriv.
20	14-13;14	Exact diff; line integ.
21	15-1	Double integrals
22	15-2;3	Area; physical appl.
23	15-4	Polar coordinates
24	15-5;6	Triple integ; cyl. coord.
25	15-7;8	Phys. appl; spher. coord.
26	16-1	Surface area
27	16-1;2	Defin; typical series
28	16-3;4	Power series; geom. ser.
29	16-5;6	Oper. with pow. series Ser. related to the GP
30	16-7	Series expansion; Taylor's series
31	16-11;12	Comp; indeter. forms
32	16-14	Convergence tests
33	16-15;16	Power ser; alter. ser.
34	17-4;6	Complex variables
35	17-7;8	Complex variables

Textbooks: Thomas - 'Calculus and Analytic Geometry'

Burington - 'Mathematical Tables and Formulas' 3rd ed.

APPENDIX 19, Section 15

INDUSTRIAL MANAGEMENT FUNDAMENTALS II

Course 15.02

Bibliography

'Managements Aims and Responsibilities, Lewis H. Brown

President, Johns-Manville Corp. (From the Proc.7th Int. Man. Cong. Washington 1938)

'Scientific Management' - a summary of the work of Taylor, Gantt, Gilbreth, Cooke, Barth, Emerson, Fayol (by the School of I.M., M.I.T.)

'The Road to High Wages and Low Labour Costs', excerpts from

'Industrial Management in Transition', George Filipetti

'Scientific Management and Labour', Robert E. Hoxil

'Scientific Management', M. B. Drury

'Mangement Principles and Philosophy' excerpts from

'Industrial Management in Transition' , George Filipetti

'Organisation of Industry', Alvin Brown

'Indirect Approach to Market Reactions', Louis Cheskon and L. B. Ward (Harvard Business Review, Sept.1948)

'Forecasting for Profit', Wilson Wright

'Essentials of Cost Accounting', Blocker

'Controlling', Robert B. Fetter (The Texas Co.)

'Government and Collective Bargaining', Fred Whitney (excerpts)

APPENDIX 19, Section 14

FUNDAMENTALS OF INDUSTRIAL MANAGEMENT I

Texts: Alt & Bradford, 'Business Economics'
Mulcahy, ed., 'Readings in Economics'

Date			Readings	Case Preparation
M	9/20	Registration Day		
W	9/22	The Business Firm: Several	A & B Pt.I	I-1 (Report of Earnings)
Th	9/23	Viewpoints and Definitions	"	I-5
M	9/27	The Business Firm: Demand	A & B Pt II	II-1, 2
W	9/29	and Revenue as a Chief	"	II-5, App. A&B
Th	9/30	Problem Area	" VIII	II-7
M	10/4	Economic Analysis in the		II-9
W	10/6	Field of Marketing		II-10(correlation)
Th	10/7	General Survey		
M	10/11	The Business Firm	A & B Pt III	III-1
W	10/13	Internal Relationships		III-4
Th	10/14	and Cost Analysis	" III,	III-5
M	10/18	Management and Technical Change: Investment	A & B Pt III	
W	10/20	Decisions vs. Determination of Technical Feasibility		
Th	10/21	Price Changes in Supply Markets		III-9 Written Case
M	10/25	Plant Visit: Cost-conscious Firm		
W	10/27	Pricing and Price Policies	A & B Pt IV	IV-5
Th	10/28		"	IV-2
M	11/1	Some determinants of Price	Clemens: to be distributed	IV-8
W	11/3	Policies	Hitch: "	IV-6
Th	11/4			Written Case or Hour exam
M	11/8	Non-Price Competition	A & B Pt V	V-1
W	11/10		A & B Pt V	V-2, 3
Th	11/11	Holiday		

APPENDIX 19, Section 14, continued.

Date		Readings	Case Preparation
M 11/15	Fluctuations in Economic		Minnesota Mining Discussion
W 11/17	Activity: Forecasting	A&B Pt.VI	VI-2
Th 11/18	and Interpretation	"	VI-1 Hand in Minnesota Mining
M 11/22	Managerial Reactions to the	"	
W 11/24	Business Cycle		VI-3, 5
Th 11/25 thru S 11/28 - Thanksgiving Recess			
M 11/29	Wage Policy of the	A&B Pt VII	
W 12/1	Individual Firm		VII-1
Th 12/2			VII-3
M 12/6		M. W. Reder	VII-4 or Peruzzi
W 12/8	Public Policy and the	A&B Pt VIII	VIII-5
Th 12/9	Firm	"	VIII-1 VIII-4
M 12/13			VIII-3
W122/15		Review	
Th 12/16		Hour Exam.	
12/18	thru 1/2 - Christmas Vacation		
M 1/3	Economic Analysis and Specific	Whitin, 'Some Business Applications'	
W 1/5	Management Problems	Alderson, 'OR & Management Problems'	
Th 1/6	Plant Visit		
M 1/10	Materials for Analysis: The		
W 1/12	Interaction Between Theory		
Th 1/13	and Practice; the Availability and evaluation of Business Data		
M 1/17			
W 1/19			
Th 1/20			

APPENDIX 19, Section 16

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Civil and Sanitary Engineering
1.601 Fluid Mechanics

Text: Rouse and Howe 'Basic Mechanics of Fluids'

Lesson	Date	Articles	
1	Sept. 22	1-2	Introduction, Fluid Properties
2	24	3	Dimensional Considerations
3	27	4	Pressure Intensity
4	29	4	" "
5	Oct. 1	5	Total Pressures
6	4	6	Buoyancy and Flotation
7	6	7	Continuity
8	8		EXAM
9	11	8	Flow Patterns
10	13	8	" "
11	15	9	Fluid Acceleration
12	18	10	Pressure Velocity Relation
13	20	10	" " "
14	22	11	Steady Flow, Energy Relations
15	25	12	" " Momentum "
16	27	12	" " " "
17	29	13	Accel. of Liquid Bodies
18	Nov. 1	13	Bernouilli Theorem
19	3		Gen. Energy Equa.-Hydr. Grad.
20	5		" " " " "
21	8		EXAM
22	10	14(A)	Gates and Sluices
23	12	14(B)	Weirs and Spillways
24	15	15(C)	Froude No. and Similarity
25	17	16	Viscosity
26	19	17	Laminar Flow
27	22	18	Reynolds No.
28	24	19	Fluid Turbulence
29	29	19	Uniform Flow in Pipes
30	Dec. 1	19	Losses in Commercial Pipes
31	3	19	" " " "
32	6		Special Friction Charts and Tables
33	8		EXAM
34	10	20(A)	Non-circular Conduits
35	13	20(B)	Open Channel Problems
36	15	20(C)	" " "
37	17	21	Transition Losses in Pipes
38	Jan. 3	21	" " " "
39	5		Std. Orifice and Venturi Coeff.
40	7		Branching and Parallel Pipes
41			
42	10	22	Surface Resistance
42	12	22	" "
44	14	23	Drag - 3 Dim. Bodies
45	17	23	" " "
46	19	24	Drag - 2 dim. "

APPENDIX 19, Section 17

2.4 Heat Engineering

Schedule of Assignments

Date			Reading (Text: Thermodynamics - Keenan)
1	Sept.	21	Chapter I
2		22	
3		23	
4		24	
5		28	Chapter II
6		29	
7		30	Chapter III
8	Oct.	4	
9		5	
10		6	
11		7	QUIZ
12		11	Chapter IV
13		13	
14		14	
15		18	
16		19	Chapter V
17		20	
18		21	
19		25	
20		26	
21		27	
22		28	QUIZ
23	Nov.	1	Chapter VI
24		2	
25		3	Chapter VII
26		4	
27		8	
28		9	
29		10	QUIZ
30		15	Chapter VIII

APPENDIX 19, Section 18.

2.42 Heat Engineering

Schedule for First Half of Term

Symbols -
K - Keenan, 'Thermodynamics'
S - 'Problems in Heat Engineering'
A - Special Problems to be handed out by instructor.

Date			Reading
1	Feb.	9	Organisation
2		11	Heat Transfer Notes
3		15	
4		16	
5		18	
6		23	
7		25	K XI - Pg.136-148
8	Mar.	1	
9		2	
10		4	Quiz
11		8	K XI - Pg.148-168
12		9	
13		11	
14		15	
15		16	
16		18	
17		22	Chemical Reaction Notes
18		23	K XIV
19		25	KXVI
20	Apr.	5	KXVII
21		6	Quiz
22		8	

Schedule for Second Half of Term

23		12	Gas turbine Notes
24		13	
25		15	
26		20	K XVI
27		22	
28		26	
29		27	
30		29	
31	May	3	Quiz
32		4	K XII
33		6	
34		10	
35		11	
36		13	
37		17	K XV
38		18	K XV
39		20	Quiz
40		24	
41		25	

APPENDIX 19, Section 19.

3.11 Lecture & Recitation Schedule

(Text: 'Metallurgy for Engineers', Wulff, Taylor, Shaler.)

Sept.	T	21	Organisation
	W	22	Introduction
	T	23	Crystal Structure
	M	27	Crystal Structure
	T	28	Crystal Structure
	W	29	Solidification of Pure Metals
	T	30	Solidification
Oct.	M	4	Binary Alloys
	T	5	Binary alloys
	W	6	Binary Alloys
	T	7	Binary Alloys
	M	11	Binary Alloys
	T	12	Holiday
	W	13	Industrial Nonferrous Alloys
	T	14	Binary Alloys (precipitation hardening)
	M	18	Casting
	T	19	Binary Alloys (solidification)
	W	20	Casting
	T	21	Binary Alloys (review)
	M	25	Quiz I
	T	26	Discuss Quiz
	W	27	Iron Carbon Alloys
	T	28	Iron Carbon Alloys
Nov.	M	1	Iron Carbon Alloys
	T	2	Iron Carbon Alloys
	W	3	Cast Iron
	T	4	Transformation in Steel
	M	8	" "
	T	9	" "
	W	10	" "
	T	11	Holiday
	M	15	Heat Treatment of Steel
	T	16	Transformation in Steel
	W	17	Quiz II
	T	18	Discuss Quiz
	M	22	Heat and Surface Treatment of Steel
	T	23	" " " " "
	W	24	Welding
	T	25	"
	M	29	"
	T	30	"

APPENDIX 19, Section 19, continued.

Dec.	W 1	Metal Working
	T 2	" "
	M 6	" "
	T 7	" "
	W 8	" "
	T 9	" "
	M 13	Quiz III
	T 14	Discuss Quiz
	W 15	Alloying Elements in Iron and Steel
	T 16	" " " " "
		Christmas Vacation
Jan.	M 3	Heat and Corrosion Resistant Alloys
	T 4	" " " " "
	W 5	Corrosion
	T 6	"
	M 10	Electrical and Magnetic Properties
	T 11	" " " "
	W 12	Quiz IV
	T 13	Discuss Quiz
	M 17	To be arranged
	T 18	"
	W 19	"

APPENDIX 19, Section 20.

'Economics' by Paul A. Samuelson,
Prof. of Economics, M.I.T.

Part One: Basic Economic Concepts and National Income

Chapter	1	Introduction. Scope and limitations
	2	Central problems of every economic society
	3	Functioning of a mixed capitalistic enterprise system
	4	Individual and family income
	5	Income from Agriculture, property and labour
	6	Business organisation and income
	7	The economic role of government: Expenditure, regulation and finance
	8	" " " " " Federal Taxation and local finance
	9	Labour and industrial relations
	10	Personal finance and social security
	11	National income

Part Two Determination of National Income and its Fluctuations

Chapter	12	Saving Consumption and Investment
	13	The theory of income determination
	14	Prices and Money
	15	Fundamentals of the Banking system and deposit creation
	16	Money, interest and income
	17	Federal reserve and central bank monetary policy
	18	The business cycle
	19	Fiscal policy and full employment without inflatiom

Part Three

Chapter	20	Determination of price by supply and demand
	21	Supply and demand continued
	22	The dynamics of speculation and risk
	23	The theory of consumption and demand
	24	Equilibrium of the firm: Cost and Revenue
	25	Patterns of imperfect competition
Part Four	26	Theory of Production and marginal products
	27	Pricing of factors of production
	28	Competitive wages and collective bargaining
	29	Interest and capital
	30	Profits and incentives

Part Five International Trade and Finance

Chapter	31	The balance of international payments
	32	Postwar international economic problems
	33	International trade and the theory of comparative advantage
	34	The economics of tariff protection and free trade

Part Six Alternative Economic systems

Although Samuelson's book refers mainly to the American economic system, there is much useful information of a general character. The book is well written and has the advantage of being up-to-date, using data as late as 1950.

APPENDIX 19, Section 21.

15.41 Introduction to Business Finance — Course Calendar and Assignment Sheet.

Date		Discussion Topic	Assigned Reading
W Sept.	22	Introduction	Text, Chap. I
F	24		
M	27		
W	29	Business Population and organization	Text, Chaps II-IV, XIV-XVI
F Oct.	1		
M	4		
W	6		
F	8		
M	11		
W	13	Financial analysis and planning	Howard & Upton Chaps 3-12
F	15		
M	18		
W	20		
F	22	Hour exam	
M Nov	1	Financial instruments	Text, Chaps XII, V-X, XVIII
F	12	Monetary Policy	The Federal Reserve System, Its purposes and functions
W	24	Security markets and investment banking	Text, Chap XVII, XIX-XXI
W Dec.	1	Hour exam	
M	6	Short- and Intermediate-term financing	Howard & Upton Chaps 13-18
W	15	Income determination	Text, Chap XXII
W Jan	5	Dividend policy	Text, Chaps XXIV-XXV
W	12	Reorganization	Text, Chaps XXVIII, XXX-XXXIII
M	17	Hour exam	

Texts: Husband and Dockeray, 'Modern Corporation Finance, 3rd ed. (Richard D. Irwin, 1952)

Anderson, 'Cases in Corporatopm Finance', (Rinehart & Co. 1954)

Supplementary Readings: Howard & Upton 'Intro. to Business Finance' (McGraw-Hill 1953)

APPENDIX 19, Section 22

15.50 ACCOUNTING

Assignment Sheet : Text - 'Accounting - A Management Approach', Robrett, Hill and Beckett

Date		Readings	Written Problems	Lab. Problems
Sept.	21	Registration Day		
	23	Class organization		
	24	No Lab		
	25	'The Characteristics of Business Capital' Chap I.	I-35	
	28	'Modifications of Revenue' Chap II	II-31	
	30	Previous assignment continued	III-23	
Oct.	1			II-33
	2	Remainder of Chap III		
	5	Previous assignment continued	III-30	
	77	Neuner, 'Cost Accountigg' - Chap III	Neuner 3-4	
	8	(problem to be distributed)		Burney & Co.
	12	Holiday		
	14	Ch. XIII	XIII-11	
	15			Burney Co, contd.
	16	Previous assignment continued		
	19	" " "	XIII-32	
	21	Review		
	22	Exam		
	23	Chap IV		
	26	Previous assignment continued	IV-32	
	28	Chap V	V-18	
	29			IV-33
	30	Previous assignment continued		
Nov.	2	Chaps VI & VII	VII-29	
	4	Annual reports - to be distributed		
	5			VI-34
	6	Review Chaps IV-VII		
	9	Chap IX	IX-20	
	11	Holiday		
	12			XVII-27
	13	AAA, 'Price Level changes and Financial Statements' and Gordon, 'The Valuation of Accounts at Current Cost' - to be distributed		

APPENDIX 19, Section 22 continued.

Date		Readings	Written Problems	Lab Problems
Nov.	16	Ch . X	X-30	
	18	Brundage 'Development of LIFO in the U.S.A.' and AIA, 'Changing concepts of Business Income' - Sec.8 - to be distributed		
	19			X-32
	20	Review Chs.IX & X		
	23	Exam.		
	25	Ch. XI	XI-31	
	30	Remainder of Ch.VIII and Appendix	XI-10 & App.2	
Dec.	2	Dumont Co. - to be distributed		
	3	Problem to be distributed		Trumbull & Suburban Co.
	4	Hicks, 'Costs for Management Decisions' - to be distributed		
	7	Ch.XII	XII-23	
	9	West et al. v. Chesapeake & Potomac Telephone Co. of Baltimore - to be distributed		
	10			XII-16 & 30
	11	Ch.XV		
	14	Ch.XVI and AAA 'Reserves and Retained Income' - to be distributed		
	16	Chs.XV & XVI continued	XVI-26	
	17			XV-33
	18	Review Chs.XI-XVI		
		- Christmas Vacation -		
Jan	4	Wellington, A Primer on Budgeting, Chs.1 through 5	XIII-25	
	6	Wellington - Chs.6 through 12	XIV-32	
	8	Ch.XIV		
	11	Previous assignment continued	XVII-25	
	13	Dean, 'Cost Structures and Break-even Charts' - to be distributed	XVII-26	
	14	Blick Chemical Co. - to be distrib.		
	18	Review Ch. XVII	Blick Co.	
	20	Review - Lang, 'Concepts of Cost, Past and Present' - to be distributed		

APPENDIX 19, Section 23

PRODUCTION MANAGEMENT 15.71

Recommended Reading:

Alford, 'Principles of Industrial Management'
Anderson, Mandeville & Anderson 'Industrial Management'
Bethel, Ativater, Smith and Stockman 'Industrial Organisation'and Management'
Cornell, 'Organisation and Management
Davis, 'Industrial Organisation and Management'
Knowles and Thompson, 'Industrial Management'
Lansburgh & Spriegel, 'Industrial Management'
Mitchell, 'Organisation and Management of Production'
Taylor, 'Scientific Management'

Material Used in the Course:

'The Hawthorne Experiments' adapted from 'Management and the Worker' by F.J. Roethlisberger and William J. Dickson.
'Overcoming resistance to change' by Lester Coch and J.R.P. French Jr.
'The Role of Standards in the System of Free Enterprise' by Howard Coonley and P.G. Agnew (Am. Stand. Assoc. 70E 45th St.,N.Y.17)
'Inventory Control in Theory and Practice' by T.M. Whitin, Quarterly Journal of Economics.
'An Electro-Analogue Method for Investigating Problems in Economic Dynamics' by N.F. Morehouse, R.H. Strotz and S.J. Horowitz, from Econometrica, Oct. 1950.
'Manufacturing Progress Functions', by Werner Z. Hirsch, from 'The Review of Economic Statistics'
'Some Applications of Operations Research in Industry', by O. W. Hamilton, The United States Time Corporation
'Feedback' by Arnold Tustin, from Scientific American Sept.1952.
'Control Systems' by Gordon S. Brown and Donald P. Campbell, from Scientific American, Sept.1952
'Economic Quality Control of Manufactured Product', by W.A. Stewart, paper presented before A.A.A.S. on Dec 28th 1929 at Des Moines, Iowa.
'The Role of Statistics as a Tool of Management' by J. M. Juran, from Mechanical Engineering, April 1949, pp 321-324.
'Statistical Quality Control' by Eugene L. Grant pp.311-325
'The Technique of Experimenting in the Factory' by Leonard A. Seder, Gillette Safety Razor Co.
'Control Chart Method of Controlling Quality during Production', American War Standards, A.S.A. 70E 45th St., N.Y.17.

15.61 BUSINESS LAW

During the term you will be asked to write abstracts of various cases. The following is a suggested form:

RIGS v. SOKEL

318 Mass. 337 (1945)

FACTS: The Defendant applied for a renewal of his beer and wine license after refusing to perform a contract to sell his restaurant business to the Plaintiff. As a result the Plaintiff's application for the same license was refused, and he brought this Bill for specific performance of the contract. The lower court, after finding that a $500 liquidated damage provision in the contract was inadequate, ordered the Defendant to execute a lease and bill of sale, and enjoined him from interfering with the Plaintiff's application for a license, said order to be dissolved if the Plaintiff failed to obtain a license in a reasonable time.

ISSUES: 1. Is this type of situation where specific performance and injunctive relief will lie, or did the Plaintiff have an adequate remedy at law by reason of the liquidated damage provision?

2. Did the parties intend the damage provision to be an alternative performance, thus barring remedies for non-performance?

HOLDING 1. Decree of specific performance and injunction affirmed. There was no adequate remedy at law.

2. The damage provision was not a bar to other remedies.

GROUNDS 1. There was a finding of fact that $500 did not adequately compensate the Plaintiff for his expenditure; the property sought by the Plaintiff was 'Unique', being among other things a lease.

2. Unless otherwise stated in the contract, it is presumed that damages are intended merely as security for performance.

RULES 1. Where property pertains to land and is 'unique' the law considers it irreplaceable and allows specific performance on the theory that money damages are inadequate.

2. The intention of the parties governs.

COMMENT This case illustrates the extent to which a court will go to give the plaintiff adequate relief. Here they had to circumvent the contingency involved in the granting of a beer and wine license.

APPENDIX 19, Section 26

Text

Smith, George A., 'Policy Formulation and Administration', Chicago, Irwin, 1953

Readings:

Davis, Ralph C., 'Fundamentals of Top Management', New York, Harper & Brothers, 1951.

Newman, W. H., 'Administrative Action', New York, Prentic-Hall, 1951.

Barnard, Chester I., 'The Functions of the Executive', Cambridge, Harvard University Press, 1938.

Pigors, Paul and Faith, 'Let's Talk Policy', Publications in Social Science, Series 2, No.29.

Joynt , John B., 'Management's Basic Function: Policy Formulation Part I,' Advanced Management, August 1954, pp 11-13

APPENDIX 19, Section 25

TECHNIQUE OF EXECUTIVE CONTROL 15.90

Objectives of course:

1. To demonstrate the nature of administrative problems by case illustration.
2. To examine current administrative practice in the organisation and control of industrial enterprise.
3. To examine characteristic problems of relations with subordinates, associates and supervisors.
4. To introduce some recently developed approaches to the analysis of organisational behaviour.
5. To become familiar with current administrative practice by intensive in-plant investigation.
6. To examine the changing conditions under which industrial enterprise operates.

	Class Programme	Assignments
I	Introduction & statement of problem Wed. Feb. 10, Fri. Feb. 12	
II	Current Admin. Practice. Wed. Feb. 17, Fri. Feb. 19 " " 24, " " 26 " Mar. 3, " Mar. 5	Date Past One " " Two
III	Technique of Executive Control Wed. Mar. 10, Fri. Mar. 12 " " 17, " " 19	Schell 1-VIII Dubin 7, 9 Schell IX Schell X-XIII Dubin 16
IV	Analysis of Organisational Behaviour Wed. Mar. 24, Fri. Mar. 26 " Apr. 7, " Apr. 9 " " 14, " " 16	Brown 1-IV Dubin 2, 11, 17 Brown V-IX Dubin 12, 13, 15 Dubin 20, 21
V	Field Investigation Wed. Apr. 28 - Fri. May 14	Field Reports
VI	Dynamics of Industrial Enterprise Wed. May. 19 - Fri. May 21	Schell XIV-XV Dubin 19 Final Exam.

APPENDIX 20

College of Engineering Syracuse University

Industrial Engineering 175

Engineering Economic Analysis

1. Introduction

The problem of what to include and what not to include in a four-year engineering curriculum is an acute one. In the face of an ever-broadening field, it is becoming increasingly difficult ot offer a student, in four short years, all the basic knowledge, concepts, and techniques that fir him for an engineering career. Therefore, it is important that he, and his teachers, ask of every course he proposes to take, "How can the inclusion of this course, in preference to all alternatives, be justified?"

How can a course in Engineering Economic Analysis be justified? Perhaps this can best be answered by quoting the first two paragraphs of preface to the text used:

"Nearly all engineering problems involve considerations and comparisons of cost." Arthur M. Wellington's classic remark, made nearly fifty years ago, that engineering was the art of doing well for one dollar what any bungler could do for two dollars, was his striking way of emphasising this fact. In most cases the costs which are to be compared are not immediate costs, but rather costs in the long run.

"The recent survey by the Society for the Promotion of Engineering Education brought out clearly the fact that among engineering graduates there is a general feeling that the most serious omission in their technical education was the failure to emphasize the economic aspects of engineering. In this connection, what the engineering student needs most of all is a point of view - the point of view that ultimate economy is a problem with which the engineer must be concerned. This point of view involves the realization that quite as definite a body of principles governs the economic aspects. The importance of engineering economy is likely to be more effectively emphasized and the principles of comparison more likely to be covered with less duplication of effort, if these principles are presented in a separate course."

II Major purposes of the Course

A. Concepts -

To develop in the engineering student:

1. An appreciation of the important role that cost plays in most engineering decisions - that no engineering problem is complete without a cost study.
2. The concept that cost is a function of time.

APPENDIX 20 continued.

3. The realization that factors that cannot be reduced to the common denominator of dollars must be considered in an economy study.
4. The realization that all economy studies are based on prediction of future events.
5. The firm knowledge that, as an economy study, past events are irrelevant except as they aid in the prediction of the future.
6. The realization that the principles of engineering economy are applicable in all branches of engineering.
7. An appreciation of the great importance of selling the results of an economy study to management
8. An awareness of the social implications of economy studies
9. The concept of the economic life of an asset (in contradistinction to its physical life or depreciation period).
10. The importance of considering all logical alternatives in an economy study.
11. Appreciation of the fact that determining the exact nature of the problem, and then the factors required for its solution, are often the most difficult part of actual economy studies.
12. Realization that it is <u>prospective differences</u> between alternatives that are relevant in their comparisons.

B. Techniques

1. Develop a systematic approach to engineering economy studies and apply this approach to increasingly complex situation, utilizing examples from all fields of engineering.
2. Develop the mathematics of the time value of money and apply them in increasingly complex situations.
3. Examine the differences in purpose between accounting and economy studies and the resultant uses and limitations of accounting figures in economy studies.
4. Introduce the basic principles of probability as applied to economy studies.
5. Examine recent developments in the field of machine replacement studies.
6. Examine the influence of the sources of investment funds on economic analysis.
7. Examine the effects of income taxes and government regulations on economic analysis.
8. Encourage students to develop self-propelling interests in the field of engineering economic analysis.

APPENDIX 20. continued (3)

III Methods of Teaching

1. Lecture sessions will be reduced to a minimum. In general, lectures will cover only points which, from past experience, tend to cause difficulty to students.

2. Many sessions will be devoted to problems, attention being directed more at the attack on the problem than on the solution obtained.

3. Open book quizzes, both announced and unannounced, will be quite frequent. These will frequently be based on the problems accompanying the text. (There are 400 of these, of which about 100 are accompanied by answers.)

4. Encouragement will be offered, without compulsion, to do a representative sampling of the problems accompanying the text.

5. Formal daily assignments will not be given. The student will be expected to keep somewhat ahead of current classroom discussion. In general, the order of presentation found in the text will be followed. Supplementary reading will occasionally be assigned.

6. A term project will be expected of all graduate students.

IV Text

Grant, 'Principles of Engineering Economy', 3rd edition, Ronald Press, New York, 1950.

V Supplementary Reading

Bullinger, C. E., 'Engineering Economic Analysis'

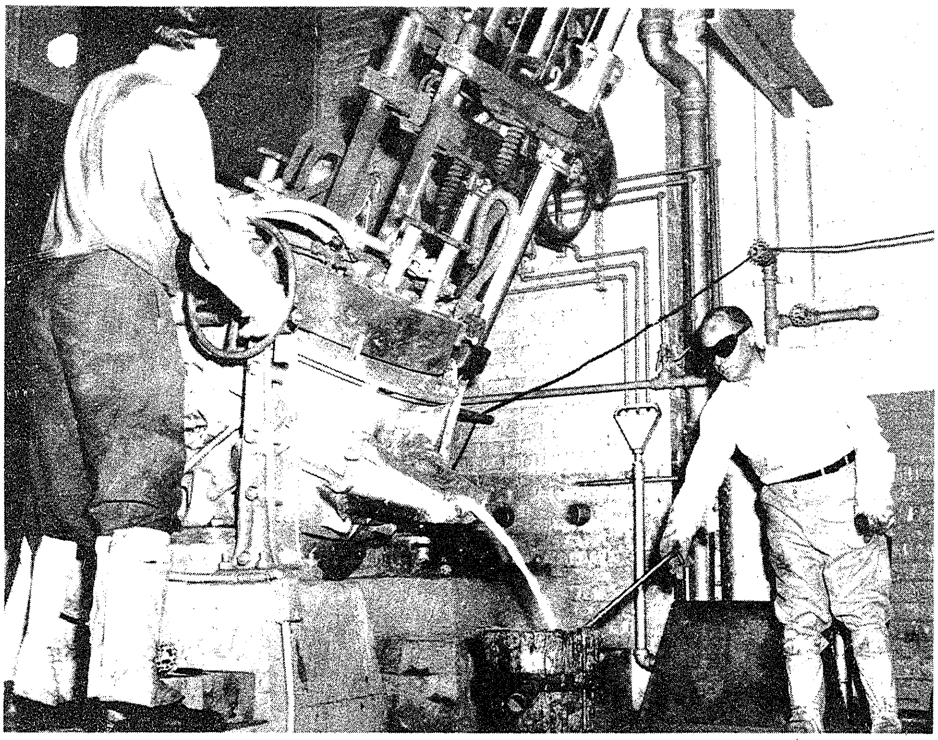
Terborgh, George, 'Dynamic Equipment Policy'

Thuesen, H. G. 'Engineering Economy'

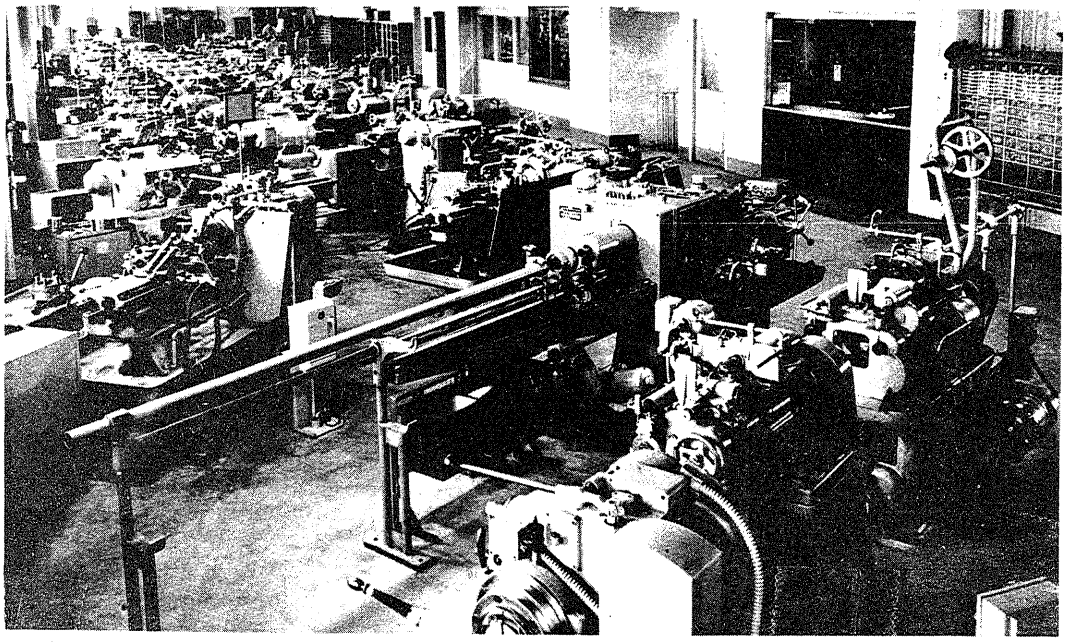
Grant and Norton, 'Depreciation'

MAPI Replacement Manuel

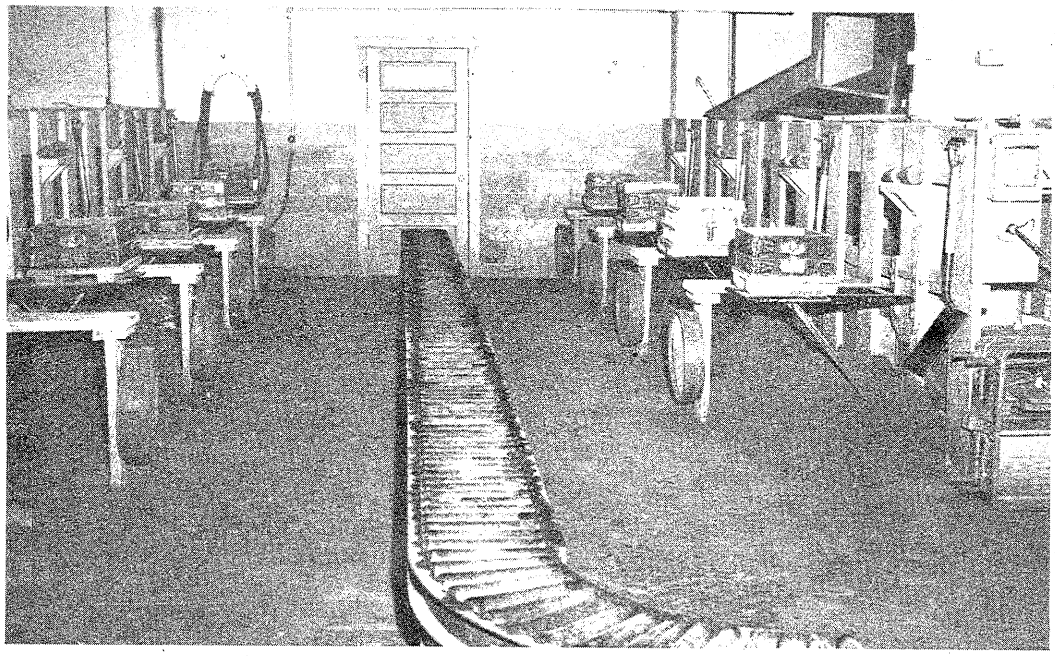
APPENDIX 21



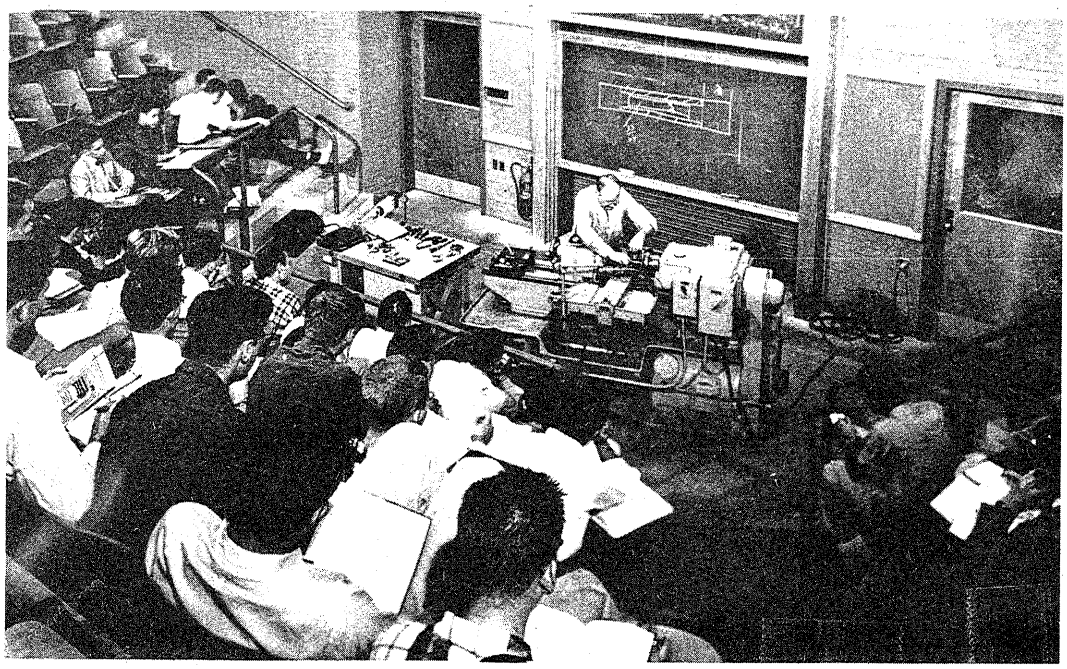
UNIVERSITY OF ILLINOIS, Navy Pier, Chicago. Pouring cast-iron from a three-phase electric furnace (one of the fastest units in the country)



MASSACHUSETTS INSTITUTE OF TECHNOLOGY. Turning Section of Machine Tool Laboratory.



UNIVERSITY OF ILLINOIS, Navy Pier, Chicago.
Centre bay of Foundry Laboratory, showing moulding stations and conveyor.



MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Machine tool lecture in progress.