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MECHANICAL TECHNOLOGY, DESIGN AND PRODUCTION, A SUGGESTED 2-YEAR POST HIGH SCHOOL CURRICULUM.

OFFICE OF EDUCATION, WASHINGTON, D.C.

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THE PURPOSE OF THIS CURRICULUM GUIDE IS TO ASSIST ADMINISTRATORS, SUPERVISORS, AND TEACHERS TO PLAN AND DEVELOP 2-YEAR POST-SECONDARY EDUCATION PROGRAMS IN MECHANICAL DESIGN AND PRODUCTION. TECHNICAL MATERIALS WERE DEVELOPED BY AN INSTITUTE STAFF FOR THE WISCONSIN STATE BOARD FOR VOCATIONAL EDUCATION UNDER CONTRACT TO THE U.S. OFFICE OF EDUCATION (USOE) AND INCLUDE SUGGESTIONS FROM OTHER INSTITUTIONS. ENGINEERS, EDUCATORS, AND USOE STAFF MEMBERS REVIEWED THE MATERIALS PRIOR TO PUBLICATION. THE CURRICULUM IS DESIGNED TO PROVIDE MAXIMUM TECHNICAL INSTRUCTION IN THE TIME ALLOTTED, AND SUPPORTING SCIENTIFIC COURSES ARE COORDINATED WITH TECHNICAL COURSES. THE OBJECTIVE OF THE CURRICULUM IS TO PREPARE TECHNICIANS FOR ENTRY, ADVANCEMENT, AND FURTHER STUDY IN THE TECHNOLOGY. THE 2-YEAR CURRICULUM IS DESCRIBED, CLASSIFIED, AND SCHEDULED FOR BOTH DESIGN AND PRODUCTION OPTIONS. COURSE DESCRIPTIONS INCLUDE TIME ALLOTMENTS, UNIT OUTLINES, LABORATORY ACTIVITIES, TEXTS, REFERENCES, AND VISUAL AIDS. A BIBLIOGRAPHY IS INCLUDED. THE APPENDIX INCLUDES SAMPLE INSTRUCTIONAL MATERIAL AND A DESCRIPTION OF SUGGESTED INSTRUCTIONAL FACILITIES. THIS DOCUMENT IS AVAILABLE AS GPO NUMBER FS 5.280--80019 FOR 70 CENTS FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402. (JM)

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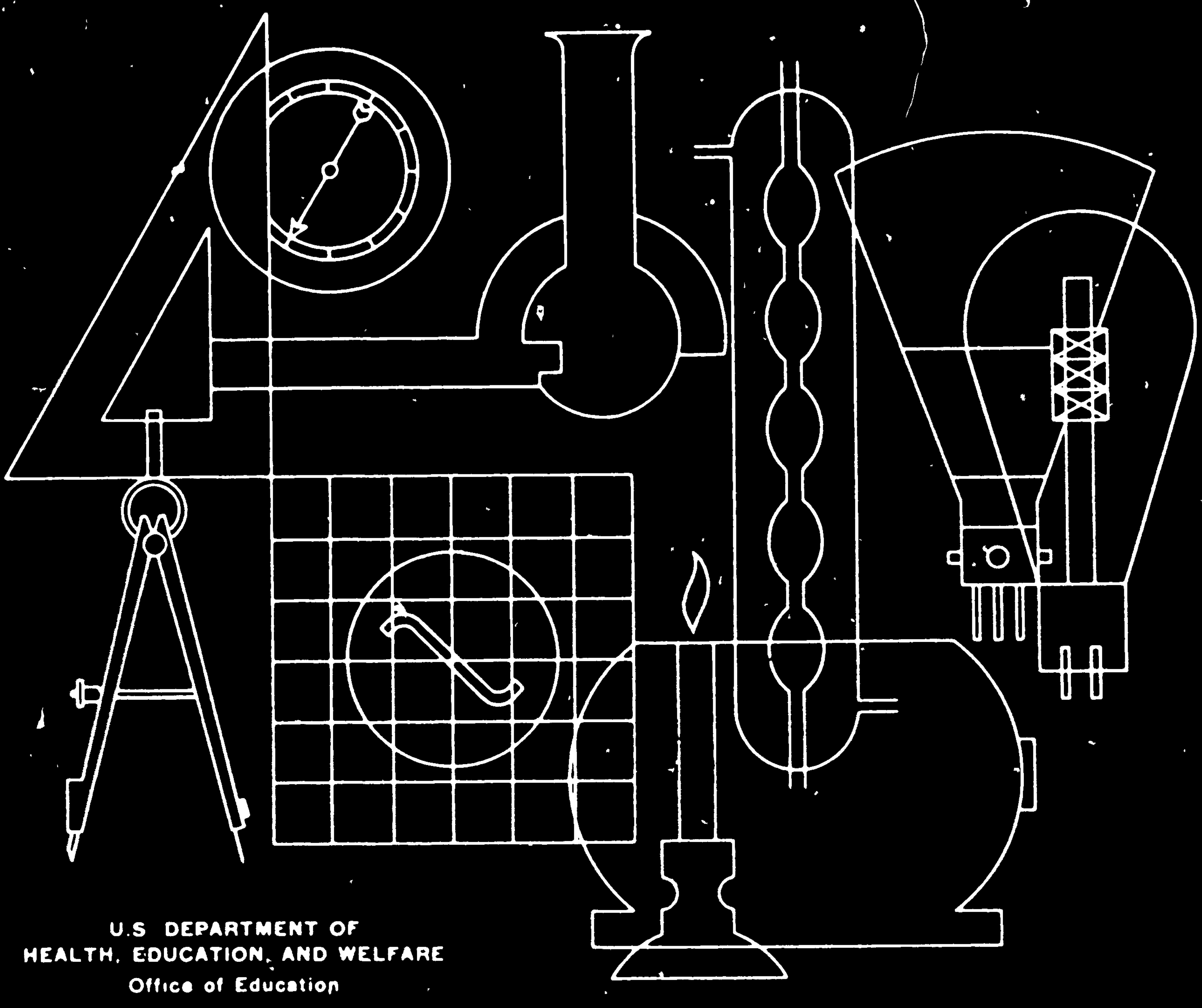
TECHNICAL EDUCATION PROGRAM SERIES NO. 3

Mechanical Technology

Design and Production

A Suggested 2-Year

Post High School Curriculum



U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Office of Education

OE-80019

TECHNICAL EDUCATION PROGRAM SERIES NO. 3

MECHANICAL TECHNOLOGY

Design and Production

A Suggested 2-Year Post High School Curriculum

U.S. DEPARTMENT OF
HEALTH EDUCATION AND WELFARE . . . . . . ANTHONY J. CELEBREZZE, *Secretary*
Office of Education . . . . WAYNE O. REED, *Acting Commissioner*

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Foreword

EDUCATION for technological change is our bridge to the new age of nuclear power. Human energy—human capacity for labor—must be translated into human capacity to master new techniques and new mechanisms.

Technical personnel in the modern industrial complex must have broad training in established fields of technology. Mechanical technology is one of those fields. All of the activities that support the work of the mechanical engineer require knowledge and understanding on the part of the engineer's team.

This curriculum guide was prepared to help in planning and developing technical education programs in mechanical design and production. It includes suggested 2-year curriculums in mechanical design technology and mechanical production technology. It offers suggested course outlines, suggested laboratory layouts, texts and references, and sample instructional materials—all presented as aids to the school administrators, supervisors and teachers who will be planning and promoting new programs of mechanical technology. It may be used, too, in evaluating existing programs. Although the indicated level of instruction in this suggested curriculum is post high school, the sequence of course work may well start at any grade level where students have the prerequisite background and understanding.

The technical materials included herein were prepared by the staff of the Milwaukee Institute of Technology, acting for the Wisconsin State Board for Vocational Education, pursuant to a contract with the U.S. Office of Education. Many useful suggestions were obtained from special consultants and from administrators and teachers in schools of technology. Although all suggestions could not be incorporated, each was considered carefully in the light of the publication's intended use. In view of this it should not be inferred that the curriculum is completely endorsed by any one institution, agency, or person.

The technical accuracy of the curriculum materials is due largely to the work of a group of eight outstanding engineers and educators who thoroughly reviewed these materials in conference with the staff of the Technical Education Branch in the U.S. Office of Education.

WALTER M. ARNOLD
Assistant Commissioner for
Vocational and Technical Education

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Boston, Mass.

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[1] Public educational institutions
[2] Federal laboratory

Contents

Mechanical Technology Program

General Requirements

THE EDUCATION PROGRAM described in this publication is organized to provide 2 years of full-time study in the broad field of mechanical technology. The course work in the suggested curriculum is designed to provide depth of understanding in the technical requirements of occupations in modern mechanical design and mechanical production.

The work of technical personnel in a modern industrial enterprise is closely related to scientific and engineering developments which involve the use of new materials, new processes, and new methods of production. To function in this complex, the worker requires certain abilities—the technical skills which form the basis of technology curriculums. These abilities have been broadly defined as follows:[1]

1. Facility with mathematics; ability to use algebra and trigonometry as tools in the development of ideas that make use of scientific and engineering principles; an understanding of, though not necessarily facility with, higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology.
2. Proficiency in the application of physical science principles, including the basic concepts and laws of physics and chemistry that are pertinent to the individual's field of technology.
3. An understanding of the materials and processes commonly used in the technology.
4. An extensive knowledge of a field of specialization, with an understanding of the engineering and scientific activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to do such work as detail design using established design procedures.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.

Mechanical technology is an integral and important part of several areas of industrial activity that incorporate machines, mechanisms, and industrial processes. In general, the functions performed by technically trained personnel in these industries are part of research and engineering activities, or they are related to these activities in such a way as to require a broad understanding of engineering design and production. It is convenient for educational purposes to group these functions in two general areas: design and production. Accordingly, the materials in this guide have been organized to provide a two-option curriculum consisting of one common year of course work with second-year options in either design or production.

The design option provides the educational background necessary for many functions of such jobs as design draftsman, tool designer, research assistant, or engineering assistant. The curriculum is designed to provide the broad technical competence needed for these jobs rather than the specific skills or techniques required for a single-skill occupation. The instruction centers around *occupational elements that normally cannot be obtained through experience alone*—elements such as physical metallurgy, materials and processes, and principles of machine design.

The production option, as the name implies, is organized for concentration on mechanical manufacturing functions. It is pointed toward occupations such as quality-control technician, production planner, methods analyst, and job esti-

[1] Division of Vocational Education, U.S. Office of Education. *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs.* Washington: U.S. Government Printing Office, 1962. (OE-80015) p. 5.

mator. As in the design option, the objectives are broad rather than highly specialized. Here again the purpose is not to prepare for single or limited-skill jobs but for multiple-responsibility occupations which require an understanding of engineering functions—particularly those of production engineering—in metal working and allied industries.

The mechanical technology curriculum is designed for high school graduates (or the equivalent) who have particular abilities and interests. In general, students entering the program should have completed 1½ years of algebra, 1 year of geometry, and 1 year of a physical science in their high school program. It should be recognized that the ability levels of those who do and those who do not meet these general requirements will vary greatly and that some students may have to take refresher courses in mathematics or English to make satisfactory progress in the program.

Because of the specialized nature of this curriculum, teachers must have special competencies. These competencies are based primarily on technical knowledge and industrial experience. Beyond this, however, an instructor of mechanical technology courses must understand the educational philosophy, the objectives, and the unique organizational requirements that characterize technical education programs.[2] Instruction in the technical education program is not a matter of conducting independent classes in discrete subjects; all courses are closely interrelated.

A 2-year curriculum must concentrate on primary needs if it is to prepare individuals for responsible technical positions in modern industry. It must be honestly pragmatic in its approach and must involve a high order of specialization. *The curriculum suggested in this bulletin has been designed to provide maximum technical instruction in the time that is scheduled.* To those who are not familiar with this type of educational service (or with the goals and interests of students who elect it) the technical program often appears to be inordinately rigid and restrictive. While modifications may be necessary in certain individual institutions, the basic structure and content of this curriculum should be maintained.

A technical curriculum usually has five subject-matter divisions, namely: (1) specialized technical courses in the technology, (2) auxiliary or supporting technical courses, (3) mathematics courses, (4) science courses, and (5) general education courses. The technical subjects provide application of scientific and engineering principles. *For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program.* This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first 2 terms, a curriculum principle that will be illustrated at several points. General education courses constitute a relatively small part of the total curriculum. It has been found that students who enter a technical program do so because of the depth in the field of specialization that the program provides. In fact, many students who elect this type of educational program will bring to it a good background of general study.

Equipment and facilities for a mechanical technology program must meet high qualitative standards, since the strength of the program lies in providing a variety of engineering and scientific applications. Laboratories are required for this type of instruction—not workshops. In training technical workers for mechanical design and production, competency is needed in the use of metallurgical laboratory equipment, precision measuring and computing devices, and scientific and engineering handbooks, as well as some knowledge of machine tools.

Variety and quality are more significant than quantity in equipping a technical laboratory. In terms of total investment the mechanical technology program is costly, although schools that have shop facilities may be able to use them for certain parts of the curriculum proposed here.

Communication is an important element of technical work. The educational program should include specific instruction in graphic, written, and oral communications. In addition to these specifics, there should be a continual emphasis on written reports with a rising standard of attainment as the student progresses in the program. Elements of industrial sociology, psychology, and economics, while necessarily limited by the time factor, should be considered important units of the curriculum.

The course outlines in this guide are short and descriptive. The individual instructor will have to prepare complete courses of study and arrange

[2] Ibid., p. 10–17.

the curriculum material in logical order of teaching before starting instruction. Sample instructional materials found in the appendix may be helpful to instructors in preparing units of instruction.

The material is not intended to be applied to a given situation exactly as outlined; it is presented to illustrate the form and content of a complete mechanical technology program. In keeping with the form of previously published guides, it is planned as a full-time post high school preparatory program. It is expected, however, that these materials will be of use also in planning extension courses and preparatory technical programs in secondary schools.

The Curriculum

A 2-year technology program has certain unique requirements that influence the content and organization of the curriculum. Some of these requirements are imposed by the occupational functions that graduates must be prepared to perform; some result from the need for special courses that will maximize the effectiveness of teachers who have special competencies; and others arise because of the need to teach both technical principles and industrial applications in the limited time available. The mechanical technology curriculum reflects three basic requirements: functional utility, units of instruction in specialized technical subjects, and provision for the teaching of principles by application. In addition, the curriculum includes general education values which are essential in today's dynamic social order.

Functional competence in a broad field such as mechanical technology has at least three components around which the curriculum must be structured: (1) The training should prepare the graduate to take an entry job in which he will be productive; (2) the broad, technical training, together with a reasonable amount of experience, should enable the graduate to advance to positions of increasing responsibility; and (3) the foundation provided by the training should be broad enough so that the graduate can do further study within his field of technology. This curriculum has been designed to meet these three requirements.

The Design Option

A graduate of the design option should be able to perform satisfactorily in entry jobs such as draftsman, engineering assistant, or developmental laboratory technician. Competency in drafting is developed by providing extensive drafting laboratory time in five courses having a combined total of 612 contact hours. Course work in metallurgy, heat treatment, tool design, and machine design provides the breadth of understanding needed for the more advanced positions in mechanical design. The entire 2-year design program is coordinated by the planned interrelationship of mathematics, science, and technical courses. An introductory design course in the third term provides illustrations and applications of concepts being learned concurrently in the strength-of-materials laboratory. In the fourth term a design-problem course parallels courses in machine design and tool design.

The Production Option

The production option of this curriculum has been organized to make effective use of the instructional facilities required for the design option. The primary emphasis is on manufacturing and production in the metal-working industries. A graduate of this option should qualify for an entry position in one of several manufacturing functions. Methods analysis, production planning, and quality control are typical areas in which the graduate should be able to function with a minimum of on-the-job training.

The first 2 terms of the production option are identical to the first 2 terms of the design option. It is expected that students will choose either the design or production option at the beginning of the third term on the basis of their interests and abilities. In the third and fourth terms of the production option the emphasis is on the methods

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Design Major

(72 credit hours)

First Year

Course No.	Course title	Class hours	Laboratory hours	Total hours	Credit hours
	First term	16	9	25	18
G 100	Orientation	1	0	1	0
DP 103	Materials of Industry	3	0	3	3
DP 104	Mechanical Drafting I	2	6	8	4
DP 113	Manufacturing Processes I	2	3	5	3
M 115	Mathematics I	5	0	5	5
G 123	Communication Skills	3	0	3	3
	Second term	14	11	25	18
A 132	Technical Reporting	2	0	2	2
DP 133	Manufacturing Processes II	2	3	5	3
DP 134	Mechanical Drafting II	2	6	8	4
M 144	Mathematics II	4	0	4	4
S 145	Mechanics and Heat	4	2	6	5

Second Year

Course No.	Course title	Class hours	Laboratory hours	Total hours	Credit hours
	Third term	12	15	27	18
A 204	Strength of Materials	3	2	5	4
D 205	Basic Mechanisms	2	9	11	5
S 214	Electricity	3	2	5	4
G 222	American Institutions	2	0	2	2
S 223	Hydraulics and Pneumatics	2	2	4	3
	Fourth term	11	15	26	18
D 233	Machine Design	3	0	3	3
D 234	Basic Tool Design	1	6	7	4
D 235	Design Problems	1	9	10	5
G 283	Psychology and Human Relations	3	0	3	3
A 293	Industrial Organizations and Institutions	3	0	3	3

A—Auxiliary or supporting technical courses
D—Specialized courses (Design major)
DP—Specialized courses common to both design and production majors
G—General courses
M—Mathematics courses
S—Science courses

and procedures of industrial production. The problem-solving approach is used to a large extent, especially in the fourth term, to give as broad a perspective as possible and to make full use of previous course work in process and production planning, plant layout, statistics, and the factors of quality-cost-ratio analysis.

Curriculum Parameters

In technical curriculums it is mandatory that specialized technical course work be introduced in the first term. Deferring this introduction even for one term imposes serious limitations on the effectiveness of the total curriculum. Several important advantages accrue from the early introduction of the technical specialty. For one thing, student interest is caught by practical aspects. If the first term consists entirely of general subjects—mathematics, English, social studies—students often lose interest. Also, by introducing technical study in the first term it is possible to obtain greater depth of penetration in specialized subjects in the latter stages of the 2-year program. Another important factor is the opportunity to apply the mathematics in the technical courses. The student's study in mathematics is reinforced by his appreciation of the disciplinary values obtained therefrom and the need for these values in technical study.

As the student progresses, he is encouraged to do more and more individual work, making use of previously learned concepts in machine processes, production methods, and the characteristics of the materials used in modern industry. The

Production Major

(70 credit hours)

First Year

Course No.	Course title	Class hours	Laboratory hours	Total hours	Credit hours
First term		**16**	**9**	**25**	**18**
G 100	Orientation	1	0	1	0
DP 103	Materials of Industry	3	0	3	3
DP 104	Mechanical Drafting I	2	6	8	4
DP 113	Manufacturing Processes I	2	3	5	3
M 115	Mathematics I	5	0	5	5
G 123	Communication Skills	3	0	3	3
Second term		**14**	**11**	**25**	**18**
A 132	Technical Reporting	2	0	2	2
DP 133	Manufacturing Processes II	2	3	5	3
DP 134	Mechanical Drafting II	2	6	8	4
M 144	Mathematics II	4	0	4	4
S 145	Mechanics and Heat	4	2	6	5

Second Year

Course No.	Course title	Class hours	Laboratory hours	Total hours	Credit hours
Third term		**12**	**9**	**21**	**16**
P 204	Methods and Operations Analysis	3	3	6	4
A 213	Statistics and Quality Control	2	2	4	3
S 214	Electricity	3	2	5	4
G 222	American Institutions	2	0	2	2
S 223	Hydraulics and Pneumatics	2	2	4	3
Fourth term		**13**	**15**	**28**	**18**
P 234	Plant Layout and Materials Handling	3	3	6	4
P 244	Process Planning	3	3	6	4
P 254	Production Problems	1	9	10	4
G 283	Psychology and Human Relations	3	0	3	3
A 293	Industrial Organizations and Institutions	3	0	3	3

A—Auxiliary or supporting technical courses
DP—Specialized courses common to both design and production majors
G—General courses
M—Mathematics courses
P—Specialized courses (Production major)
S—Science courses

ability to do independent work in which decision-making is involved is one of the important criteria for advancement in technical occupations. The curriculum also provides for the study of communication skills and an introduction to the social and economic structure of industry—important aspects of the student's preparation for positions of responsibility.

A basic element of the program, that of preparation for continuing study and improvement, is provided, in the main, by the foundation obtained in mathematics and science. The amount of time devoted to formal course work in these disciplines is 374 contact hours; however, this figure is not an accurate indicator of the mathematics and science content of the curriculum. Facility with mathematics and with the use of scientific principles is developed by applying these constructs in technical courses throughout the 2-year curriculums. A better measure of the student's performance level in these disciplines is found in the content of advanced courses such as machine design. The effect of this curriculum design is an integration of the subjects, as contrasted to the treatment of subjects as discrete and independent units in the more traditional pre-engineering programs. In the latter, for example, foundation courses in mathematics and science usually precede the specialized study and little or no attention is given to applications.

Outside study is a significant part of the student's total program. In this curriculum, 2 hours of outside study time have been suggested for each hour of scheduled class time. A typical weekly work schedule for a student in this curriculum would be: class attendance, 14 hours;

laboratory, 10 hours; outside study, 28 hours—a total of 52 hours per week.

The course outlines shown are concise and comprehensive, intended as guides rather than as specific plans of instruction to be covered in an inflexible order or sequence. They represent a judgment on the relative importance of each instructional unit, especially where time estimates are shown for the divisions within each course. It is expected that the principles outlined in these courses will be supplemented with industrial applications wherever possible. Industrial parctices should be studied and followed in drafting and report writing, and materials from industry should be utilized throughout the program wherever it is possible to do so. Field trips will add a great deal to the effectiveness of the instruction if they are carefully planned and scheduled. The texts and references listed may serve as a guide in the selection of instructional aids. Instructors will want to make their own selections for each course to effect the best possible coordination with the instructional materials and the textbooks used in other courses. There are undoubtedly other excellent volumes which have not been included.

This publication is intended as a guide for program planning and development, primarily in post high school institutions. It is expected that adaptations will need to be made to suit various situations in several kinds of schools. The level of instruction indicated represents a consensus on the level of proficiency required for success in occupations in which manpower is in short supply today and threatens to be even more so in the future. The curriculum is a product of the efforts of a number of people—educators, engineers, employers, and the staff of the Technical Education Branch—concerned with the improvement of public education services.

Course Outlines

Technical Courses

DESIGN AND PRODUCTION

DP 103, Materials of Industry

Hours Required

Class, 3; Laboratory, 0

Description

Modern industry utilizes a variety of engineering materials with which the student in mechanical technology must be familiar. A study is made of the five general classifications of materials and their application to industrial uses. Special emphasis is given to new materials which have been developed through technological advances.

Major Divisions

	Class hours
I. Ferrous Metals	18
II. Nonferrous Metals	18
III. Wood products	3
IV. Nonmetallic Materials	3
V. Miscellaneous Materials	9

I. Ferrous Metals—18 hours
   1. Historical sketch
   2. General properties
   3. Sources and classes
   4. Smelting and refining
   5. Processing
   6. Alloy classifications
   7. Forming and fabrication
   8. Special processing

II. Nonferrous Metals—18 hours
   1. Historical sketch
   2. General properties
   3. Sources and classes
   4. Smelting and refining
   5. Processing
   6. Alloy classifications
   7. Forming and fabrication
   8. Special processing

III. Wood Products—3 hours
   1. Classification
   2. General properties affecting use
   3. General industrial applications

IV. Nonmetallic Materials—3 hours
   1. Classification
   2. General properties affecting use of each

V. Miscellaneous Materials—9 hours
   1. Historical development
   2. Classification
   3. General properties affecting use of each

Texts and References

AUSLEY. *Manufacturing Methods and Processes*
BACHA. *Elements of Engineering Materials*
BEGEMAN. *Manufacturing Processes*
CAMPBELL. *Principles of Manufacturing Materials and Processes*
CLARK. *Engineering Materials and Processes*
COMMITTEE ON ENGINEERING MATERIALS. *Engineering Materials*
DEGARMO. *Materials and Processes in Manufacturing*
KEYSER. *Materials of Engineering*
MANTELL. *Engineering Materials Handbook*
MERSEREAU. *Materials of Industry*
MOORE and MOORE. *Materials of Engineering*

[1] See Bibliography for publishers.

DP 104, Mechanical Drafting I

Hours Required

Class and Laboratory, 8

Description

This is a beginning course for students who have had little or no previous experience in drafting. The principal objectives are: basic understanding of orthographic projection; skill in orthographic, isometric, and oblique sketching and drawing; ability to produce accurate and complete detail and assembly working drawings; understanding of principles and appropriate applications of descriptive geometry; experience in using handbooks and other resource materials; elementary understanding of design principles in machine parts used as drawing projects; and use of simplified drafting practices in industry. A.S.A. standards are stressed. Interpretation of industrial sketches and prints is introduced when feasible not only to emphasize accepted drawing practices but also to develop an early appreciation of one of the functions involved in the "production" option.

Major Divisions

		Class and laboratory hours
I.	Fundamentals	10
II.	Technical Sketching, Orthographic Projection	16
III.	Isometric and Oblique Pictorial Sketching	14
IV.	Dimensioning	10
V.	Sections	10
VI.	Auxiliary Views	14
VII.	Revolution (Rotation)	10
VIII.	Threads, Fasteners, Springs	14
IX.	Working Drawings: Detail Drawings	18
X.	Working Drawings: Assembly Drawings	16

I. Fundamentals—10 hours
- A. Class
  1. Function of drafting in design and production
  2. Drafting instruments, materials, and equipment
     - a. Care and use
     - b. Current drafting practices in industry
  3. Lettering
     - a. Construction of Vertical Gothic capitals
       - (1) Proportion and spacing
       - (2) Numerals and fractions
     - b. Identification of other styles and alphabets
     - c. Lettering instruments, tools, and devices
  4. Geometrical constructions (accurate notes required)
     - a. Geometric forms and shapes
     - b. Geometry applied to drafting problems
     - c. Constructions involving straight lines, angles, circles, arcs, tangents, ellipses, parabolas, hyperbolas, helices, involutes, and cycloids
- B. Laboratory
  1. Draw with pencil on vellum or tracing paper two or more mechanical parts or objects (single view) which provide an opportunity to use basic drawing instruments, stress accuracy in full-scale measurement, make first applications of vertical gothic lettering; utilize basic geometrical constructions; and make typical sheet layouts.
  2. Reproduce first drawings as a device for critical analysis of line quality. Compare with quality of good industrial prints. This practice is followed periodically throughout the course.

II. Technical Sketching, Orthographic Projection—16 hours
- A. Class
  1. Sketching materials
  2. Sketching techniques

3. Theory of third-angle orthographic projection
   a. Definition
   b. Planes of projection
      (1) Frontal
      (2) Horizontal
      (3) Profile
   c. Introduction of principles of descriptive geometry
      (1) Locating points in space
      (2) Locating lines in space
      (3) Locating surfaces in space
   d. Edges and surfaces
      (1) Parallel
      (2) Inclines
      (3) Oblique
      (4) Curved
      (5) Truncated
   e. Fillets, rounds, and runouts
4. Multiview sketches: 2-view, 3-view
   a. View relationships
      (1) Principles of projection
      (2) Selection of views for best shape description
   b. Steps in sketching
      (1) Estimating size and proportion of objects
      (2) Determination of appropriate scale for sketch
      (3) Centering sketch on pad or sheet selected
      (4) Blocking in shapes of views
         (a) Construction lines
         (b) Solid lines
         (c) Center lines
         (d) Hidden lines
      (5) Projecting views
         (a) Spaces between views
         (b) Transfer of measurements
      (6) Order of sketching
      (7) Quality of finished sketch
   c. Techniques for sketching circles, ellipses, and other shapes
   d. Analysis of engineering drawings and sketches from industry
   e. Alphabet of lines
   f. Explanation of first-angle projection

B. Laboratory
1. Examine several three-view drawings and sketch in any missing lines.
2. In several problems where two views of an object are given, sketch a third view.
3. Sketch three-view drawings from pictorial representations of selected machine parts or objects, using cross-section paper.
4. Sketch three-view drawings from actual machine parts or objects, using sketch pad or tracing paper.
5. Using drafting instruments and equipment, make three-view drawings of selected machine parts involving the principles and techniques covered in the units of instruction. Make drawings on vellum or tracing paper.
6. Reproduce one or more of the mechanical drawings as a basis for discussion of line equality.

III. Isometric and Oblique Pictorial Sketching—14 hours

A. Class
1. Isometric sketching
   a. Materials
   b. Principles
      (1) Isometric projection
      (2) Isometric drawing
   c. Techniques
      (1) Blacking in
      (2) Isometric and nonisometric lines
      (3) Angles in isometric drawing
      (4) Isometric ellipses
      (5) Arcs and curves
      (6) Sections
      (7) Intersections
2. Oblique sketching
   a. Cavalier drawing principles
   b. Cabinet drawing principles
   c. Positioning of object
   d. Steps in oblique drawing
   e. Offset measurements
   f. Ellipses
   g. Arcs and curves
   h. Angles
   i. Sections

B. Laboratory
1. Using isometric paper, make several isometric sketches from three-view drawings provided by the instructor, incorporating the principles taught in Unit 1 of Division III.

2. Using cross-section paper, make several oblique drawings (sketches from drawings or objects providod by the instructor), incorporating the principles taught in Unit 2 of Division III.

IV. Dimensioning—10 hours

A. Class
1. Theory of dimensions
   a. True-position dimensions
   b. Maximum material position
2. Technique of dimensioning
   a. Lines
   b. Arrowheads
   c. Fractional and decimal dimensions
   d. Leaders
   e. Fillets and rounds
   f. Finish marks
   g. Notes
3. Selection of dimensions
4. Placement of dimensions
5. Examination, analysis, and interpretation of dimensioning practices on engineering drawing or prints from local industry
6. Rules for dimensioning isometric and oblique drawings

B. Laboratory
1. Using the drawings made in Division II and Division III projects, add the needed dimensions and notes.
2. Sketch or use drawing instruments in making a more complex three-view drawing from pictorial views or actual objects involving inclined surfaces, holes, rounds, and unusual shapes which require a variety of dimensioning techniques and considerable judgment in the selection and placement of dimensions and notes.

V. Sections—10 hours

A. Class
1. Functions of sectional views
2. The cutting plane
   a. Representation on working drawing
   b. Location of cutting plane line
   c. Direction of sight
3. Conventions
   a. Cutting plane lines
   b. Section lines (A.S.A.)
   c. Spokes, arms, ribs, and lugs in section
   d. Breaks
4. Classification of sections
   a. Full sections
   b. Half sections
   c. Broken out sections
   d. Revolved sections
   e. Aligned sections
5. Dimensioning

B. Laboratory
1. Sketch or draw section views in drawings requiring several types of sections. The drawings may be provided by the instructor and completed by the student or drawn entirely by the student.

VI. Auxiliary Views—14 hours

A. Class
1. Function of auxiliary views
2. Classification of surfaces
3. Primary auxiliary views—width, depth, height, auxiliaries
   a. Direction of sight
   b. Reference plane
   c. Projection technique
   d. Transfer of measurements
   e. Auxiliary view from a principal view
   f. Principal view from an auxiliary view
   g. Dihedral angles
   h. Plotted curves
4. Partial auxiliary views
5. Half auxiliary views
6. Auxiliary sections
7. Secondary auxiliary views
8. Descriptive geometry applied to true measurements of lines, angles and surfaces

B. Laboratory
1. From 2- or 3-view drawings supplied by the instructor, sketch auxiliary views in their proper relationship to the given views.
2. Using instruments, make a working drawing which includes both primary and secondary auxiliary views.

VII. Revolution (Rotation)—10 hours

A. Class
1. Uses of revolution
   a. Locate alternate position of moving parts.
   b. Apply orthographic projection principles.

2. Principles of revolution
   a. Primary revolution—axis perpendicular to frontal plane
   b. Primary revolution—axis perpendicular to horizontal plane
   c. Primary revolution—axis perpendicular to profile plane
3. Successive revolutions
4. Applications of descriptive geometry
   a. Finding true length of lines by revolving into the principal planes
   b. Finding true shape of plane surfaces
   c. Revolution of a circle
5. Revolution conventions
6. Counterrevolution

B. Laboratory
1. Construct views of lines by the revolution method when slopes are given.
2. Draw three views of a solid object. Make successive rotations of this object. After each rotation draw the new position of each view.
3. Complete views of a tilted object by counterrevolution.

VIII. Threads, Fasteners, and Springs—14 hours

A. Class
1. Screw threads
   a. Types and uses
   b. Terms and definitions
   c. Thread forms, series, and classes
   d. Tapped holes
   e. Detailed representations
   f. Semi-conventional representation
   g. Conventional representations (A.S.A. thread symbols)
   h. Thread notes and specifications
2. Bolts, studs, and screws
   a. Types and uses
   b. Proportions
   c. Detailed and conventional representations
   d. Notes and specifications
3. Keys and pins
   a. Types and uses
   b. Detailed and conventional representations
   c. Notes and specifications
4. Rivets
   a. Types and uses
   b. Proportions
   c. Detailed and conventional representations
   d. Notes and specifications
5. Springs
   a. Types and uses
   b. Detailed and conventional representation
   c. Notes and specifications

B. Laboratory
1. Draw sufficient detail representations of more common threads, fasteners, and springs to develop understandings of their use and application in machine design.
2. Draw objects that involve conventional representations of threads, fasteners, and springs in machine assemblies and design. Provide experience in selecting size, noting specifications, and using handbook sources.

IX. Working Drawings: Detail Drawings—18 hours

A. Class
1. Relationships
   a. To design drawings or sketches
   b. To assembly drawings
2. Engineering procedure
3. Types of detail drawings
4. Representation of standard parts
5. Title and record strips
6. Determination of views needed
7. Determination of number of details on sheet
8. Zoning or positioning of drawings
9. Numbering systems for sets of drawings
10. Identifying drawings with parts list
11. Checking
12. Alterations
13. Filings and storing

B. Laboratory
1. Make finished detail drawings from an assembly layout, using accepted conventions and practices. Obtain dimensions of standard parts from catalogues and handbook.

2. Analyze prints of typical detail drawings prepared and used in local industry to become acquainted with accepted usage and procedure.

X. Working Drawings: Assembly Drawings—16 hours

A. Class

1. Types of assembly drawings
   a. Design assemblies
   b. General assemblies
   c. Working drawing assemblies
   d. Installation assemblies
   e. Check assemblies
   f. Subassemblies
2. Assembly sectioning
   a. Cut surfaces
   b. Adjacent parts
   c. Thin parts
   d. Treatment of bolts, nuts, shafts, keys, screws, spokes, ribs, gear teeth, etc. in assembly sections
   e. Symbols for section lining
3. Identification of parts
   a. Numbering parts
   b. Parts list
4. Simplified drawing practices
   a. Word descriptions vs. drawing
   b. Views needed
   c. Repetitive detail
   d. Freehand vs. mechanical representations
   e. Labor-saving devices

B. Laboratory

1. Make a general assembly drawing from detail drawings prepared in the previous assignment or provided by the instructor. Supply a complete parts list.
2. Analyze prints of typical assembly drawings and component detail drawings prepared and used in local industry for accuracy, ease of interpretation, and identification of accepted drawing room practices.

Text and References [1]

DOUGLASS and ADAMS. *Elements of Nomography*
FRENCH and TURNBULL. *Lessons in Lettering*
FRENCH and VIERCK. *A Manual of Engineering Drawing for Students and Draftsmen*
——— and ———. *Graphic Science*
GIACHINO and BEUKENA. *Engineering—Technical Drafting and Graphics*
GIESECKE, MITCHELL, and SPENCER. *Technical Drawing*
HOELSCHER and SPRINGER. *Engineering Drawing and Geometry*
LEGRAND. *The American Machinists' Handbook*
LUZADDER. *Fundamentals of Engineering Drawing*
MILLAR and SHIELDS. *Descriptive Geometry*
OBERG, ERIK, and JONES. *Machinery's Handbook*
ORTH, WORSENCRAFT, and DOKE. *Theory and Practice of Engineering Drawing*
PARE, LOVING, and HILL. *Descriptive Geometry*
SCHUMANN. *Technical Drafting*
SHUPE and MACHOVIA. *A Manual of Engineering Geometry and Graphics for Students and Draftsmen*
SPENCER. *Basic Technical Drafting*
U.S. DEPARTMENT OF COMMERCE, National Bureau of Standards. *Screw-Thread Standards for Federal Services*
ZIPPRICH. *Freehand Drafting*
ZOZZORA. *Engineering Drawing*

Visual Aids

Chicago Board of Education, 228 N. LaSalle St., Chicago, Ill.: *The Draftsman*

McGraw-Hill Book Co., Inc., New York, N.Y.:
According to Plan: Introduction to Engineering Drawing
Auxiliary Views: Single Auxiliaries
Auxiliary Views: Double Auxiliaries
Drawings and the Shop
Language of Drawing, The
Orthographic Projection
Pictorial Sketching
Selection of Dimensions
Sections and Conventions
Shape Description, Parts I and II
Shop Drawing, Part 2
Size Description

Pennsylvania State College Film Library, State College, Pa.: *Drafting Tips, Part II*

Purdue University, Lafayette, Ind.:
Capital Letters
Use of T-Square and Triangles

[1] See Bibliography for publishers.

DP 113, Manufacturing Processes I

Hours Required

Class, 2; Laboratory 3

Description

An understanding of present-day manufacturing processes is of extreme importance to students in this technology. This course is designed to provide a background of knowledge covering the various manufacturing materials and the fundamental types of manufacturing methods as employed in cold working processes. Through lecture, demonstration, and practical applications the student is given the opportunity to become familiar with the various types of machine tools, tooling, measuring, and inspection procedures. Automation is introduced and information is presented to acquaint the student with the modern practices of numerical control for machine tools and the uses of transfer and special machines.

Major Divisions

	Class hours	Laboratory hours
I. Introduction to Production Processes (Engineered Manufacturing)	1	0
II. Ferrous and Nonferrous Metals and Materials	2	0
III. Machining and Cutting Tools	3	9
IV. Plastics	2	3
V. Powder Metal and Cermets	1	0
VI. Measuring	2	6
VII. Gaging and Inspection	2	3
VIII. Turning Lathes	1	9
IX. Turret and Automatic Lathes	2	6
X. Screw Threads	1	0
XI. Drilling	1	3
XII. Boring	1	0
XIII. Planing, Shaping, and Slotting	1	3
XIV. Milling	2	6
XV. Broaching and Sawing	1	0
XVI. Grinding and Finishes	1	3
XVII. Gearing	1	0
XVIII. Metal Forming	2	0
XIX. Metal Finishing	1	0
XX. Automation	2	0
XXI. Numerical Control for Machine Tools	2	0
XXII. Transfer and Special Machines	2	0

I. Introduction to Production Processes (Engineered Manufacturing)
- A. Class—1 hour
  1. Course objectives
  2. General class procedure
  3. Tour of facilities
- B. Laboratory—0 hours

II. Ferrous and Nonferrous Metals and Materials
- A. Class—2 hours
  1. Derivation of materials
  2. Variation in physical properties
     - a. Machineability
     - b. Methods of forming
     - c. Possible service life
- B. Laboratory—0 hours

III. Machining and Cutting Tools
- A. Class—3 hours
  1. Principles of metal cutting
     - a. Types of machines and their tooling
     - b. Machineability
       - (1) Methods of measuring and reporting machineability
       - (2) Ratings
       - (3) Uses of machineability ratings
         - (a) Guide in selecting material from cost standpoint
         - (b) Standards for machining
         - (c) Estimated machining time for new jobs
       - (4) Factors affecting machineability
  2. Metal cutting
- B. Laboratory—9 hours

  Perform machine tool operations to process specified projects.

IV. Plastics
- A. Class—2 hours
  1. Basic terminology and materials
     - a. Thermosetting characteristics
     - b. Thermoplastic characteristics
     - c. Terminology
     - d. Thermosetting molding materials—forms, properties, and characteristics

e. Thermoplastic molding materials—forms, properties, and characteristics
2. Molding practices for thermosetting materials
a. Compression molding
b. Transfer molding
c. Cold molding
d. Laminating
3. Molding practice for thermoplastic materials
a. Injection
b. Extrusion
c. Blow
d. Vacuum
e. Other techniques
4. Other materials and processes
a. Plastisols
b. Adhesives
c. Finishing

B. Laboratory— 3 hours
Perform machine tool operations on plastics. Calculate cutting speeds, feeds, and rpm's.

V. Powder Metal and Cermets
A. Class—1 hour
1. General introduction
2. Processing methods
3. Application
B. Laboratory—0 hours

VI. Measuring
A. Class—2 hours
1. Direct measurements
2. Comparative measurements
3. Precision measurement
4. Visual measurement
B. Laboratory—6 hours
Measure specified projects requiring various gages, linear and measuring instruments.

VII. Gaging and Inspection
A. Class—2 hours
1. Interchangeability of parts
2. Measuring standards
3. Tolerances and allowances
4. Dial gages
5. Angular measurement
6. Optical measuring
B. Laboratory—3 hours
Take measurements and calculate angular dimensions and determine accuracies using optical methods.

VIII. Turning Lathes
A. Class—1 hour
1. Types
2. Construction and design
3. Operations
B. Laboratory—9 hours
Make setup and perform turning operations on selected projects.

IX. Turret and Automatic Lathes
A. Class—2 hours
1. Types
2. Construction and design
3. Operations
4. Principles of multiple tooling
B. Laboratory—6 hours
Perform turning operations on selected projects.

X. Screw Threads
A. Class—1 hour
1. Types
2. Elements
3. Methods of producing
B. Laboratory—0 hours

XI. Drilling
A. Class—1 hour
1. Types
a. Machines
b. Drills
2. Construction and design
3. Operations
B. Laboratory—3 hours
Set up and calculate drill speeds, feeds, and drilling, reaming, and counterboring time on selected projects.

XII. Boring
A. Class—1 hour
1. Types of machines
2. Types of tools
B. Laboratory—0 hours

XIII. Planing, Shaping, and Slotting
A. Class—1 hour
1. Types
2. Construction and design
3. Operations
B. Laboratory—3 hours
1. Set up and perform operations on selected projects.

2. Calculate strokes per minute, cutting time, and tool idle time.

XIV. Milling

A. Class—2 hours

1. Types
   a. Machines
   b. Cutters
2. Construction and design
3. Operations
4. Attachments and accessories

B. Laboratory—6 hours

1. Calculate the number of turns and select the index plate required for milling a given number of divisions.
2. Calculate the lead angle and gear ratio for milling a given helix.

XV. Broaching and Sawing

A. Class—1 hour

1. Types
   a. Machines
   b. Tools
2. Methods
   a. Operations
   b. Setups

B. Laboratory—0 hours

XVI. Grinding and Finishes

A. Class—1 hour

1. Types
   a. Machines
   b. Grinding wheels
2. Operations
3. Surface finishes
   a. Classification
   b. Measurement

B. Laboratory—3 hours

1. Set up and perform operations on selected projects.
2. Determine wheel type, spindle, and peripheral speed and grinding time on selected projects.

XVII. Gearing

A. Class—1 hour

1. Types
2. Methods of fabricating
3. Nomenclature

B. Laboratory—0 hours

XVIII. Metal Forming

A. Class—2 hours

1. Processes
2. Operations
   a. Stamping
   b. Upsetting
   c. Bending
   d. Drawing
   e. Rolling
3. Tools
   a. Types
   b. Classifications

B. Laboratory—0 hours

XIX. Metal Finishing

A. Class—1 hour

1. Methods
2. Surface preparation
3. Surface protection

B. Laboratory—0 hours

XX. Automation

A. Class—2 hours

1. Definition
2. Automatic controls
   a. Types
   b. Purposes
3. Area of use
   a. Machining
   b. Steel making
   c. Materials handling
   d. Metal casting
   e. Pressworking
   f. Heat treating

B. Laboratory—0 hours

XXI. Numerical Control for Machine Tools

A. Class—2 hours

1. Definition
2. Conventional vs. numerical control method
3. Computers
4. Application potential
5. Control concepts
6. Preparation for use

7. System details
8. Transfer line

B. Laboratory—0 hours

XXII. Transfer and Special Machines

A. Class—2 hours
1. Introductory definition
2. Transfer-type machines
   a. Operation
   b. Achievement
3. Process machines
4. Sectionized automation
5. Integrated-interlocked line
6. Case studies of transfer machines

B. Laboratory—0 hours

Texts and References [1]

AMERICAN SOCIETY OF TOOL ENGINEERS. *Tool Engineers Handbook*
BEGEMAN. *Manufacturing Processes*
BURGHARDT, AXELSON, and ANDERSON. *Machine Tool Operation*, Vols. 1 and 2
CAMPBELL. *Principles of Manufacturing Materials and Processes*
DOYLE. *Metal Machining*
JEFFERSON. *The Welding Encyclopedia*
LINDE AIR PRODUCTS COMPANY. *The Oxy-Acetylene Handbook*
MAYNARD. *Industrial Engineering Handbook*
SCHALLER. *Engineering Manufacturing Methods*

[1] See Bibliography for publishers.

DP 133, Manufacturing Processes II

Hours Required

Class, 2; Laboratory, 3

Description

This course is designed to provide a background of knowledge covering the various manufacturing materials and the fundamental types of manufacturing methods as employed in hot working processes. Through lecture, demonstration, and discussion the student becomes familiar with the various types of welding processes and their applications, with special machining operations such as ultrasonic, electrical discharge, electroarc, and chemical milling, and with bonding practices and the use of adhesives in modern manufacturing. Some emphasis is also given to metallurgical practices and procedures. Practical experience is gained by the student in performing simple arc and oxyacetylene welding operations, in producing simple molds, cores, and castings, and in basic heat treating, inspection, and testing, using both destructive and nondestructive methods.

Major Divisions

Welding

	Class hours	Laboratory hours
I. Introduction to Hot Working Processes	1	0
II. History and Nomenclature	1	0
III. Welding Processes	1	3
IV. Equipment and Materials for Arc Welding	1	0
V. Procedures in Arc Welding	1	6
VI. Equipment and Materials for Oxyacetylene Welding	1	0
VII. Procedures in Oxyacetylene Welding	1	6
VIII. Welded Joints	1	3
IX. Submerged Melt and Inert Gas Shielded	1	0
X. Special Processes	2	0
XI. Welding Economy	1	1

Foundry

	Class hours	Laboratory hours
XII Introduction to Metal Casting	1	0
XIII. Founding Practices	1	3
XIV. Foundry Equipment and Materials	1	0
XV. Types of Molds	2	3
XVI. Types of Cores	1	3
XVII. Foundry Sands	1	0
XVIII. Sand Testing	1	3
XIX. Molding Machines	1	0
XX. Permanent Molding	1	3
XXI. Die Casting and Investment Casting	1	0
XXII. Casting Design and Economy	1	3

Metallurgy

	Class hours	Laboratory hours
XXIII. Metallurgy and Metals	1	0
XXIV. Heat Treating	1	3
XXV. Basic Inspection and Testing of Metals	2	6
XXVI. Basic Metallography	2	6
XXVII. Recent Developments	4	0

Welding

I. Introduction to Hot Working Processes
   A. Class—1 hour
      1. Course objectives
      2. General class procedure
      3. Tour of facilities
   B. Laboratory—0 hours

II. History and Nomenclature
   A. Class—1 hour
      1. Arc Welding—historical development
      2. Oxyacetylene welding—historical development
      3. Welding nomenclature
   B. Laboratory—0 hours

III. Welding Processes
   A. Class—1 hour
      1. Arc
      2. Gas
      3. Inert gas
      4. Brazing
      5. Forge

6. Carbon arc
7. Submerged arc

B. Laboratory—3 hours
To learn to strike an arc and maintain the proper arc length. To run beads in several directions in flat position using mild steel plate and ⅛" E6012 electrode.

IV. Equipment and Materials for Arc Welding

A. Class—1 hour
1. Safety
2. Arc welding machines and accessories
   a. Electrodes
   b. Base materials

B. Laboratory—0 hours

V. Procedures in Arc Welding

A. Class—1 hour
1. Types
2. Applications

B. Laboratory—6 hours
Weld mild steel plate in down-hand position using ⅛" E6010 and ⅛" E6011 electrode. Fabricate selected projects using arc welding equipment.

VI. Equipment and Materials for Oxyacetylene welding

A. Class—1 hour
1. Safety
2. Gas welding equipment and accessories
   a. Gas rods
   b. Base materials

B. Laboratory—0 hours

VII. Procedures in Oxyacetylene Welding

A. Class—1 hour
1. Types
2. Applications

B. Laboratory—6 hours
Light and adjust torch. Run a fusion bead in a straight line without filler rod. Run beads on mild steel plate using a filler rod. Cut specified shape using a cutting torch.

VIII. Welded Joints

A. Class—1 hour
1. Type
2. Applications
3. Welding symbols

B. Laboratory—3 hours
Fabricate selected projects using oxyacetylene welding equipment.

IX. Submerged Melt and Inert Gas Shielded

A. Class—1 hour
1. Types
2. Applications

B. Laboratory—0 hours

X. Special Processes

A. Class—2 hours
1. Classification
2. Application

B. Laboratory—0 hours

XI. Welding Economy

A. Class—1 hour
1. Welding design
2. Metal casting vs. welded fabrication
3. Manual vs. semiautomatic vs. automatic welding

B. Laboratory—0 hours

Foundry

XII. Introduction to Metal Casting

A. Class—1 hour
1. Ferrous metals
   a. Historical development
   b. Modern processing
2. Nonferrous metals and plastics
   a. Historical development
   b. Modern processing

B. Laboratory—0 hours

XIII. Foundry Practices

A. Class—1 hour
1. Patterns—construction
2. Molding considerations
   a. Sand casting
   b. Sandless casting
3. Coring considerations
4. Casting considerations
5. Gating and risering

B. Laboratory—3 hours
Temper molding sand. Make a simple drag cavity mold. (Straight parting—bench).

XIV. Foundry Equipment and Materials

A. Class—1 hour
1. Melting equipment

2. Molding equipment
   a. Machine types
3. Casting equipment
4. Foundry accessories
5. Foundry materials

B. Laboratory—0 hours

XV. Types of Molds

A. Class—2 hours
1. Classification
2. Application and use

B. Laboratory—3 hours
Make a simple drag cavity mold using a jolt-squeeze molding machine.

XVI. Types of Cores

A. Class—1 hour
1. Classification
2. Mixtures and binders
3. Core finishing

B. Laboratory—3 hours
Mix core sand with a muller. Make cores from a split, roll over, and/or vertical lift core boxes.

XVII. Foundry Sands

A. Class—1 hour
1. Natural types and uses
2. Synthetic sands and uses
3. Foundry sand preparation

B. Laboratory—0 hours

XVIII. Sand Testing

A. Class—1 hour
1. Types
2. Purposes of sand control tests
3. Sand preparation
4. Equipment used

B. Laboratory—3 hours
Make selected tests of foundry sands.

XIX. Molding Machines

A. Class—1 hour
1. Types
2. Applications

B. Laboratory—0 hours

XX. Permanent Molding

A. Class—1 hour
1. Design
2. Types
3. Uses

B. Laboratory—3 hours
Produce a nonferrous casting by making a simple drag cavity mold, pouring molten metal, shake out mold, and clean casting.

XXI. Die Casting and Investment Casting

A. Class—1 hour
1. Types of equipment
2. Applications
3. Advantages and limitations

B. Laboratory—0 hours

XXII. Casting Design and Economy

A. Class—1 hour
1. Shapes
2. Types of metals used
3. Economy of foundry practices

B. Laboratory—3 hours
Produce a ferrous casting by making a simple drag cavity mold, pouring molten metal, shake out mold, and clean casting.

Metallurgy

XXIII. Metallurgy and Metals

A. Class—1 hour
1. Definition
2. Desirable properties of metals
3. Limitations

B. Laboratory—0 hours

XXIV. Heat Treating

A. Class—1 hour
1. Types of processes and equipment
2. Applications

B. Laboratory—3 hours
Heat treat selected projects

XXV. Basic Inspection and Testing of Metals

A. Class—2 hours
1. Types of inspection and testing methods
   a. Destructive
   b. Nondestructive
2. Equipment
3. Purposes and applications

B. Laboratory—6 hours
Determine hardness of selected heat treated projects using hardness testing machines. Determine tensile strength of selected specimens. Determine shear strength of selected specimens.

XXVI. Basic Metallography
- A. Class—2 hours
  1. Terminology
  2. Equipment
  3. Applications
- B. Laboratory—6 hours
  Mount specimens and make metallographic inspection of selected specimens.

XXVII. Recent Developments
- A. Class—4 hours
  1. Electroforming
  2. Electrolytic grinding
  3. Chemical milling
  4. Ultrasonic machining
  5. Electric-discharge machining
  6. Electron beam welding
  7. Electron beam machining
- B. Laboratory—0 hours

Texts and References [1]

AMERICAN SOCIETY FOR METALS. *Metals Handbook*
AMERICAN SOCIETY OF TOOL ENGINEERS. *Tool Engineers Handbook*
BEGEMAN. *Manufacturing Processes*
BURGHARDT. *Machine Tool Operation*, Vols. 1 and 2.
CAMPBELL. *Principles of Manufacturing Materials and Processes*
DOYLE. *Metal Machining*
JEFFERSON. *The Welding Encyclopedia*
LINDE AIR PRODUCTS COMPANY. *The Oxy-Acetylene Handbook*
MAYNARD. *Industrial Engineering Handbook*
SCHALLER. *Engineering Manufacturing Methods*
STOUGHTON and BUTTS. *Engineering Metallurgy*, 3d Edition
WILLIAMS and HOMERBERG. *The Principles of Metallography*, 4th Edition

[1] See Bibliography for publishers.

DP 134, Mechanical Drafting II

Hours Required

Class and Laboratory, 8 hours

Description

This course is a continuation of DP 104. The instructional units provide additional understandings of drafting problems, skills and techniques that are essential to the work of the draftsman; emphasize design applications and the depth of background knowledge needed to carry out drafting and design functions; and *introduce* several specialized drafting areas that are equally valuable in preparation for the design and production options. As in DP 104, emphasis is placed on interpretation of industrial prints, familiarity with simplified drafting practices, ability to use handbooks and other source materials, adherence to American Standards for drafting; and the development of skill in sketching. The units dealing with design parts such as gears, cams, jigs and fixtures pave the way for greater depth of instruction in the second year design courses.

Major Divisions

		Class and laboratory hours
I.	Intersections and Developments	18
II.	Gears	18
III.	Cams	12
IV.	Jigs and Fixtures	14
V.	Architectural Drawing (Introduction)	10
VI.	Structural Drawing (Introduction)	10
VII.	Electrical-Electronics Drafting (Introduction).	8
VIII.	Pipe Drawings (Introduction)	8
IX.	Welding Drawings	8
X.	Perspective Drawing	10
XI.	Charts, Graphs, and Tables	10
XII.	Engineering Drafting Practices	10

I. Intersections and Developments—18 hours
 A. Class
  1. Intersections
   a. Classification of surfaces
    (1) Ruled surfaces
    (2) Single curved surfaces
    (3) Warped surfaces
   b. Common geometric solids
   c. Intersection of solids by planes
    (1) Plane surfaces
    (2) Curved surfaces
   d. Applications to design problems
  2. Developments
   a. Types of surfaces
    (1) Developable
    (2) Nondevelopable or approximate
   b. Types of developments
    (1) Intersection of plane and prism
    (2) Intersection of plane and cylinder
    (3) Intersection of plane and oblique prism
    (4) Intersection of plane and oblique cylinder
    (5) Intersection of plane and pyramid
    (6) Intersection of plane and cone
    (7) Truncated oblique rectangular prisms
    (8) Oblique cones (triangulation method)
    (9) Transition pieces
    (10) Intersecting prisms
    (11) Intersecting cylinders
    (12) Intersecting prisms and cones
    (13) Intersecting clyinders and cones
    (14) Intersecting cylinder and sphere
   c. Methods of development
    (1) Auxiliary views
    (2) Rotation
    (3) Triangulation
    (4) Gore method
    (5) Zone method
  3. Identification of descriptive geometry principles related to intersection and development problems and methods
  4. Identification of development problems with sheet metal layouts
 B. Laboratory
  1. Draw orthographic views of objects, preferably machine or sheet metal parts or assemblies, involving intersection of selected shapes or forms discussed in this

division of the course, and develop layouts of these objects.

2. Make a development of a transition piece involving the use of true length lines.

II. Gears—18 hours

A. Class

1. Classifications and general purposes of gears
2. Spur gear and rack drawings
   a. Gear tooth nomenclature and formulas
   b. Gear tooth shape and development
   c. Involute rack teeth
   d. Spur gear calculations
   e. Working drawings procedures including cutting data
3. Bevel gear drawings
   a. Bevel gear nomenclature and formulas
   b. Tooth development
   c. Working drawing procedures including cutting data
4. Worm and helical gear drawings
   a. Nomenclature and formulas
   b. Calculations
   c. Working drawing procedures including cutting data
5. Location of gear data in handbooks

B. Laboratory

1. Make a drawing of a spur gear and rack. Draw a few teeth only, using the circle-arc method. Dimension the drawing completely.
2. Make a complete working drawing of two mating bevel gears showing the tooth shape. Dimension completely.

III. Cams—12 hours

A. Class

1. Kinds of cams and their uses
2. Plate or disc cam
   a. Terminology—components
   b. Timing or displacement diagram
   c. Cam profile construction
   d. Pivoted and flat-faced followers
   e. Drawing principles
   f. Cam dimensions
3. Cylindrical cams
   a. Classification
      (1) Groove
      (2) End
   b. Development of cylindrical surface
   c. Drawing procedures

B. Laboratory

1. Using a set of written specifications, make a drawing of a plate cam having a roller follower with a stroke of partly uniform and partly simple harmonic motion.
2. Make a drawing of a cylindrical cam with its developed view. Use a reciprocating or swinging follower moving with a uniformly accelerating or decelerating motion.
3. Make additional displacement diagrams and developed cylinder surfaces according to specifications.

IV. Jigs and Fixtures—14 hours

A. Class

1. Definitions
2. Introduction to tool design principles
3. Introduction to jig and fixture standards
4. Types of drill jigs
   a. Plate jig
   b. Angle plate
   c. Leaf drill
   d. Shaft drill
   e. Rack and pinion
   f. Housing
5. Types of fixtures
   a. Milling fixtures
      (1) Tongues and slots
      (2) Taper grooves
   b. Broaching
   c. Boring
   d. Grinding
   e. Spot facing
   f. Tapping
6. Location of parts
7. Clamping devices and locks
8. Drill bushings
9. Drawing procedures
   a. Assemblies
   b. Details
   c. Dimensions

B. Laboratory

1. Referring to design specifications, draw a working drawing of a drill jig of moderate complexity involving an assembly and detailed drawings of parts completely dimensioned.

2. Working from design specifications, prepare complete working drawings of fixtures for a lathe or milling machine.

V. Architectural Drawing (Introduction)—10 hours
  A. Class
    1. Classification
      a. Floor plans
      b. Elevations
      c. Special layouts
      d. Sections and details
    2. Architectural drawing standards
      a. Symbols
      b. Units
      c. Handbooks
    3. Architectural drawing techniques
  B. Laboratory
    1. Analyze and interpret typical architects' blueprints, particularly those dealing with factory or commercial buildings.
    2. Draw typical detail sections.

VI. Structural Drafting (Introduction)—10 hours
  A. Class
    1. Classification of structural drawings
    2. Structural steel
      a. Shapes
      b. Connectors
      c. Floor and erection plans
      d. Riveting
      e. Welding
      f. Calculations
      g. Handbook
      h. Working drawings and conventions
    3. Timber structures
      a. Materials
      b. Trusses
      c. Connectors
      d. Working drawings and conventions
    4. Masonry structures
      a. Materials
        (1) Brick
        (2) Tile and terra cotta
        (3) Stone
      b. Basic construction details
      c. Drafting conventions
    5. Reinforced concrete
      a. Types of drawings
        (1) Engineering
        (2) Placing
      b. Manual of standard practice
      c. Drawings, sections, and conventions
  B. Laboratory
    Make detail drawings from a structural assembly.

VII. Electrical-Electronics Drafting (Introduction)—8 hours
  A. Class
    1. Diagrams
      a. Single wire
      b. Schematic
    2. Electrical drafting techniques
    3. Electrical symbols
    4. Typical electrical circuits
      a. Single and assembly
      b. Printed
    5. Electrical charts
    6. Drawing of electrical equipment
    7. Study and interpretation of industrial prints
  B. Laboratory
    1. Make a schematic diagram from a simple wiring diagram.
    2. Sketch the wiring of a room like the classroom or laboratory. Include all necessary symbols.

VIII. Pipe Drawings (Introduction)—8 hours
  A. Class
    1. Types of pipes and tubes
      a. Steel and wrought iron
      b. Cast iron
      c. Copper
    2. Pipe joints and fittings
      a. Fittings
      b. Joints
    3. Valves
      a. Globe
      b. Check
      c. Gate
    4. Pipe threads
    5. Pipe hangers and supports
    6. Pipe specifications and dimensions
    7. American Standard code
    8. Piping symbols
    9. Piping drawings
      a. Orthographic
      b. Isometric

B. Laboratory
Make a diagramatic drawing of a piping layout showing symbols for pipe fittings and valves.

IX. Welding Drawings—8 hours
A. Class
1. Use in design and fabrication of machines and structures
2. The welding process
a. Pressure welding—forging
b. Nonpressure welding
c. Resistance welding
d. Other
3. Types of welded joints
4. Arc and gas welds and symbols
5. Resistance welds and symbols
6. Welding drawings
a. Representation
b. Notes
c. Dimensioning
B. Laboratory
1. Make sketches of various types of welds and their welding symbols.
2. Make a working drawing of a welded part showing dimensions and welding symbols.

X. Perspective Drawing—10 hours
A. Class
1. Uses and applications to design drafting
2. Elements of a perspective
a. Station point—horizon line
b. Picture plane
c. Projectors—visual rays
d. Vanishing point
e. Ground line
3. Descriptive geometry principles
a. Projectors
b. Piercing points on picture plane
c. Line length in perspective
4. Location of elements
a. Station point
b. Picture plane
c. Object in relation to horizon
5. Types of perspectives
a. One-point perspective
b. Two-point perspective
c. Three-point perspective
6. Drawing procedures
a. Steps
b. Measurement of inclined lines
c. Curves and circles
7. Perspective sketching
B. Laboratory
1. Make a one-point perspective drawing of a machine part or object.
2. Make a two-point perspective drawing of a machine part or object.

XI. Charts, Graphs, and Tables—10 hours
A. Class
1. Purpose and use in engineering practice
a. Graphical presentation
b. Graphical analysis
c. Graphical computation
2. Rectangular coordinate line charts
a. Mathematical
b. Time series
c. Engineering
3. Line chart elements
a. Grids
b. Scales and scale designations
c. Points and curves
d. Titles and notes
4. Types of charts
a. Bar charts
b. Pie charts
c. Flow charts
d. Distribution charts
e. Semi-log charts
f. Other
B. Laboratory
Make rectilinear, bar, and pie charts using data or tables supplied by the instructor.

XII. Engineering Drafting Practices—10 hours
A. Class
1. Simplified drafting
a. Economy vs. clarity
b. Elimination of views
c. No scale
d. Elimination of lines and elaboration
e. Omission of circles for holes
f. Arrowless dimensions
g. Simplified base line dimensions
h. Mixed freehand and instrument drawing
i. Abbreviations
j. Templates
2. Special drafting methods and equipment
a. Special templates and lettering guides

b. Overlays
c. Photo drawings
d. Models
e. Microfilm
f. Glass tracing table
g. Special drawing instruments and equipment
h. Reproduction processes

3. Nature and use of handbooks, catalogues, and other source materials

B. Laboratory

1. Inspect and interpret industrial drawings or prints involving simplified drawing procedures.
2. Make a working drawing using simplified drawing techniques.
3. Make an ink tracing involving usual and special inking tools such as special ruling pens, drop center compass, beam compass, lettering guides, etc.

Texts and References [1]

AMERICAN INSTITUTE OF STEEL CONSTRUCTION. *Steel Construction, A Manual for Architects, Engineers, and Fabricators of Buildings and Other Steel Construction*

———. *Structural Shop Drafting*, Vols. I and II.

AMISS and JONES. *The Use of Handbook Tables and Formulas*

BUCKINGHAM. *Manual of Gear Design*

CHURCH. *Guillet's Kinematics of Machines*

DONALDSON and LACAIN. *Tool Design*

FAIRES and KEOWN. *Mechanism*

FRENCH and VIERCK, *A Manual of Engineering Drawing for Students and Draftsmen* ——— ——— *Graphic Science*

FURMAN. *Cams, Elementary and Advanced*

GIACHINO and BEUKEMA. *Engineering—Technical Drafting and Graphics*

GIESECKE, MITCHELL, and SPENCER. *Technical Drawing*

[1] See Bibliography for publishers.

GOURLEY. *Welding Symbols*

HOELSCHER and SPRINGER. *Engineering Drawing and Geometry*

JONES. *Gear Design Simplified*

KEPLER. *Basic Graphical Kinematics*

LEUCHTMAN and VEZZANI. *The Use of Machinery's Handbook*

LUZADDER. *Fundamentals of Engineering Drawing*

MILLAR and SHIELDS. *Descriptive Geometry*

OBERG and JONES. *Machinery's Handbook*

ORTH, WORSENCRAFT, and DOKE. *Theory and Practice of Engineering Drawing*

PARE, LOVING, and HILL. *Descriptive Geometry*

RAMSEY and SLEEPER. *Architectural Graphic Standards*

RULE and WATTS. *Engineering Graphics*

SCHUMANN. *Technical Drafting*

SHUPE and MACHOVIA. *A Manual of Engineering Geometry and Graphics for Students and Draftsmen*

SPENCER. *Basic Technical Drafting*

TRAUTSCHOLD. *Standard Gear Book*

WINSTON. *Machine Design*

ZOZZARD, *Engineering Drawing*

Visual Aids

Coronet Films, Coronet Building, Chicago—*Language and Graphs*

McGraw-Hill Book Co., Inc., N.Y.
Oblique Cones and Transition Developments
Shop Procedures
Simple Developments
Simple Harmonic Motion

Purdue University, Lafayette, Ind.
Ink Tracing

U.S. Navy—"United World"
Descriptive Geometry—Finding the Line of Intersection Between Two Solids.

U.S. Office of Education, Washington 25, D.C.
Principles of Gearing: An Introduction

University of California, Educational Films Department, University Extension, Los Angeles 24—*Perspective Drawing*

United World Films, Inc., 1250 Sixth Ave., New York 20.
Rectilinear Co-ordinates

DESIGN OPTION

D 205, Basic Mechanisms

Hours Required

Class, 2; Laboratory, 9

Description

A course dealing with the analysis of the motion characteristics of a mechanism of existing design and the application of this study in the design of a mechanism to provide desired motion characteristics. In the motion study, absolute and relative velocities, accelerations, and the use of instant centers are discussed. Centrodes are studied as they apply to mechanism. The uses of belts and linkages are illustrated by problems. Cam layout is taken up in detail and appropriate problems are solved. Practical problems are used in the study of gearing. Attention is also given to such mechanisms as ratchets, pantographs, valves, clutches, and universal joints.

Major Divisions

	Class hours	Laboratory hours
I. Introduction	2	0
II. Displacement, velocity, and acceleration	4	18
III. Instant Centers	2	9
IV. Plane Motion	2	9
V. Slider-Crank Mechanism	2	18
VI. Cam Displacement Diagrams	2	18
VII. Disk Cams	2	18
VIII. Miscellaneous Cams	2	9
IX. Rolling Contact	2	0
X. Spur Gears	2	9
XI. Helical Gears	2	9
XII. Worm Gears	2	9
XIII. Bevel Gears	2	9
XIV. Gear Trains	2	0
XV. Flexible Connectors	2	0
XVI. Miscellaneous Mechanism	2	9

I. Introduction
   A. Class—2 hours
      1. Orientation to the course
      2. Definition of major terms
         a. Machine
         b. Mechanism
         c. Links
         d. Motion
   B. Laboratory—0 hours

II. Displacement, Velocity, and Acceleration
   A. Class—4 hours
      1. Definition of the terms
      2. Velocity and acceleration problems
      3. Relative motion
   B. Laboratory—18 hours
      1. Lay out straight-line motion mechanism.
      2. Determine displacement ratio.
      3. Construct indicator mechanism
      4. Lay out circular path of indicator-driven mechanism.
      5. Construct Scotch yoke showing displacement, velocity, and acceleration curves. Tabulate values.

III. Instant Centers
   A. Class—2 hours
      1. Definition
      2. Kennedy's theorem
      3. Locating instant centers
      4. Describing centrodes
   B. Laboratory—9 hours
      1. Construct four-bar linkage.
      2. Locate instant centers.
      3. Lay out centrode.
      4. Lay out skeleton diagram of six-bar linkage mechanism.
      5. Locate instant centers of six-bar mechanism.

IV. Plane Motion
   A. Class—2 hours
      1. Solution of linear and angular motion problems
      2. Graphical solution of velocity and acceleration
      3. Coriolis' Law

B. Laboratory—9 hours
1. Draw four-bar mechanism in skeleton form.
2. Determine graphically velocities and acceleration.
3. Apply Coriolis' Law in above solutions.

V. Slider-Crank Mechanisms
A. Class—2 hours
1. Sliding block linkage
2. Quick return motion
3. Shaper mechanism
4. Fixed block linkage

B. Laboratory—18 hours
1. Construct skeleton diagram of a selected slider-crank mechanism.
2. Lay out the following for the above mechanism:
a. Polar velocity diagram.
b. Velocity-displacement diagram.
c. Velocity-time curve.
d. Acceleration-displacement diagram.
e. Acceleration-time diagram.
3. Calculate and construct graphical scales for velocity and acceleration.

VI. Cam Displacement Diagrams
A. Class—2 hours
1. Types of motions produced by cams
2. Cam displacement diagrams
3. Cam profile construction

B. Laboratory—18 hours
1. Construct cam displacement diagram for:
a. Uniform velocity.
b. Uniform acceleration or deceleration.
c. Simple harmonic motion.
d. Cycloidal motion.

VII. Disk Cams
A. Class—2 hours
1. Types of followers
a. Knife edge
b. Roller
c. Pivoted roller
d. Flat faced
e. Pivoted flat faced
f. Primary and secondary
2. Purpose of cams
3. Application of cams

B. Laboratory—18 hours
1. Lay out cam displacement diagram.

2. Construct cam drawing with roller follower.

VIII. Miscellaneous Cams
A. Class—2 hours
1. Cylinder
2. Positive motion
3. Circular arc
4. Automobile engine valve
5. Adjustable drum

B. Laboratory—9 hours
1. Draw a displacement diagram for cylinder cam.
2. Lay out the development of cylinder.
3. Draw a plan and an elevation of the cam.

IX. Rolling Contact
A. Class—2 hours
1. Conditions for rolling contact
2. Angular velocity ratio
3. Brush wheel and plate
4. Profile construction
5. Rolling ellipses
6. Rolling cones

B. Laboratory—0 hours

X. Spur Gears
A. Class—2 hours
1. Purpose
2. Types
3. Nomenclature
4. Theory of operation
5. Velocity ratios
6. Applications

B. Laboratory—18 hours
Draw a pair of spur gears in mesh to a predetermined gear ratio. Calculate the essential gear-tooth proportions for the 14½° full-depth involute system as well as the 20° stub involute system.

XI. Helical Gears
A. Class—2 hours
1. Purpose
2. Types
3. Nomenclature
4. Operating principle
5. Velocity ratios
6. Applications

B. Laboratory—9 hours
Lay out a pair of helical gears with selected ratio. Show both proportions and helix angle.

D 233, Machine Design

Hours Required

Class, 3; Laboratory, 0

Description

A course in which the design principles of machine elements are taken up and calculations are made in determining the size and shape of various machine parts. It includes factors which influence the selection of the materials to be used in designing such elements as beams, bearings, clutches, brakes, shafts, bushings, screws, rivets, gears, belts, and flywheels. Attention is given to various types of loading conditions, stresses, deformations, fits, finishes, and other factors which must be considered in the design of machine elements.

Major Divisions

	Class hours
I. Considerations in Machine Design	2
II. Strength of Materials Review	4
III. Fastenings	9
IV. Power Transmission	27
V. Fits and Finishes	3
VI. Problems	6

I. Considerations in Machine Design—2 hours
  1. Problem Specifications
  2. Materials
  3. Method of Manufacture
  4. Cost
  5. Assembly

II. Strength of Materials Review—4 hours
  1. Basic principles
  2. Simple and compound stresses
  3. Hollow cylinders

III. Fastenings—9 hours
  1. Rivet
  2. Screw
    a. Types of threads
    b. Application
      (1) Stud
      (2) Machine screw
      (3) Bolt
      (4) Setscrew
      (5) Washers
    c. Initial and load stress
    d. Commercial sizes
  3. Key
    a. Rectangular
    b. Woodruff
  4. Pin
    a. Straight
    b. Tapered

IV. Power Transmission—27 hours
  1. Couplings
    a. Types—sleeved or flanged
    b. Classification by action
      (1) Rigid
      (2) Sliding
      (3) Flexible
      (4) Universal
    c. Design
      (1) Empirical
      (2) Stress analysis
  2. Clutches
    a. Uses
    b. Types
      (1) Friction
      (2) Jaw
    c. Empirical design
  3. Shafts—solid and hollow
    a. Stresses
    b. Empirical formulas
    c. Commercial sizes
  4. Bearings
    a. Types
    b. Purpose
    c. Lubrication
    d. Empirical design
  5. Belts
    a. Types
      (1) Flat
      (2) Vee
      (3) Chain
    b. Materials
    c. Selection

6. Pulleys
   a. Types
   b. Rims
   c. Construction
      (1) Material
      (2) Arms
      (3) Keys
7. Flywheel
   a. Purpose
   b. Design
8. Screw
   a. Application
   b. Design
9. Gears
   a. Materials and methods of fabrication
   b. Types
      (1) Spur and pinion
      (2) Rack and pinion
      (3) Bevel
      (4) Worm and wheel
   c. Forms of teeth
      (1) 14½ degree composite
      (2) 14½ degree involute
      (3) 20 degree involute
   d. Empirical proportions
10. Cams
    a. Type
    b. Motion
11. Cranks
12. Connecting rods

V. Fits and Finishes—3 hours
1. Fits
   a. Standard fits
   b. Tolerance and allowance
2. Finish
   a. Standards
   b. Machine
   c. Grinding
   d. Lap
   e. Blast and pickle
   f. Applied

VI. Problems—6 hours

Texts and References [1]

BRADFORD. *Machine Design.*
LEGRAND. *The New American Machinists' Handbook.*
LEUTWILER. *Elements of Machine Design.*
MALEEV. *Machine Design.*
MARKS. *Mechanical Engineers Handbook.*
MERRIMAN. *Strength of Materials.*
OBERG and JONES. *Machinery's Handbook.*
ROSENTHAL and BISCHOF. *Elements of Machine Design.*
"Spiral Type Bevel Gears" in *Machinery,* Volume 23, p. 199.
"Stresses and Deflections of Shafts" in *American Machinist,* Volume 37, p. 1027 and Volume 38, p. 10.
WINSTON. *Machine Design.*

[1] See Bibliography for publishers.

D 234, Basic Tool Design

Hours Required

Class, 1; Laboratory 6

Description

Lectures, classroom discussion, and actual drawing board work are combined to help the student gain knowledge and experience necessary to design tools commonly used in modern manufacturing. The work consists of designing and laying out cutting tools, gauges, simple jigs, fixtures, and dies. Mass production methods are discussed so that the student may apply the information gained in the practical work of tool designing.

Major Divisions

	Class hours	Laboratory hours
I. The Tool Designer	1	3
II. Manufacturing Processes	1	3
III. Spring Selection	1	3
IV. Cutting Tools	2	9
V. Gauges	2	15
VI. Jigs and Fixtures	4	30
VII. Punches and Dies	4	36
VIII. Turret Lathe Tools	2	6

I. The Tool Designer
- A. Class—1 hour
  1. Manufacturing problems
     - a. Cost of selling and marketing
     - b. Cost of labor and manufacturing
     - c. Economic lot size
     - d. Machine tool line-up
     - e. Redesign for economical manufacture
     - f. The tool designer
  2. Tool drafting
     - a. Drawing technique
     - b. Standards
     - c. Checking of drawings
     - d. Catalog studies
- B. Laboratory—3 hours
  1. Redesign a workpiece for greater ease and economy in manufacturing. Make sketches with all necessary dimensions.
  2. Make a machine tool line-up for a part to be machined. List all operations in correct sequence and the type of machine to be used for each operation.

II. Manufacturing Processes
- A. Class—1 hour
  1. Primary manufacturing processes
     - a. Casting
     - b. Punch press stamping
     - c. Metal Spinning
     - d. Forging
     - e. Extruding
     - f. Molding
  2. Secondary manufacturing processes
     - a. Common machine operations
     - b. Mass production operations
  3. Tolerances and allowances
  4. Welding
- B. Laboratory—3 hours
  1. Sketch a shaft running in a bushing. Show the allowance and the tolerances of of the mating dimensions.
  2. By sketches, interpret the more commonly used welding symbols.

III. Spring Selection
- A. Class—1 hour
  1. Coil springs
     - a. Classification
     - b. Specification
     - c. Design formulas
  2. Flat springs
     - a. Classification
     - b. Design
- B. Laboratory—3 hours
  1. Calculate required size coil springs for a specific job.
  2. Calculate size of cantilever spring to given specifications.

IV. Cutting Tools
- A. Class—2 hours
  1. Single point cutting tools
     - a. Classification
     - b. Tool angles

c. Forces on cutting tools
d. Tool holders
e. Tipped tools
2. Multiple-edge cutting tools
a. Classification
b. Inserted blade cutters
3. Continuous-edge cutting tools
a. Friction saw
b. Abrasive wheels
B. Laboratory—9 hours
1. Sketch a carbide-tipped lathe cutting tool. Dimension all cutting angles.
2. Design an inserted tooth milling cutter.

V. Gauges
A. Class—2 hours
1. Fixed size gauges
a. Classification
b. "Go" and "No go" gauges
c. Gauge blocks
d. Gauge tolerances
2. Indicating gauge fixtures
a. Classification
b. Magnifying devices
c. Automatic gauges
d. Projection gauges
3. Comparative
a. Optical
b. Templates
B. Laboratory—15 hours
1. Design a flush-pin gauge to check the depth of a hole.
2. Design a template gauge to check the profile of a work-piece.
3. Design an indicator gauge fixture to check the concentricity of a shaft.

VI. Jigs and Fixtures
A. Class—4 hours
1. Classification of jigs
2. Classification of fixtures
3. Jig and fixture details
4. Design procedure
B. Laboratory—30 hours
1. Design a diameter drill jig for drilling a hole in a pin.
2. Design a milling fixture for either face milling or end milling. Provide setup gauges. State the kind and size of milling machine for which the fixture is designed.
3. Design a lathe fixture for turning, facing, boring, and tapping operations.

VII. Punches and Dies
A. Class—4 hours
1. Classification
2. Presswork operations
3. Special dies
4. Punch and die details
5. Punch and die design
B. Laboratory—36 hours
1. Design a simple blanking and piercing die to punch out a specific workpiece.
2. Design a progressive die to produce stampings according to specifications.
3. Design a bending die to perform as assigned.

VIII. Turret Lathe Tools
A. Class—2 hours
1. Turret lathe tooling
a. The turret lathe
b. General tooling principle
c. Standard turret lathe tools
2. Automatic screw machine tools
a. External turning tools
b. Internal cutting tools
c. Cam design
B. Laboratory—6 hours
1. Make an operations sheet for a workpiece to be made in a turret lathe. Sketch the turret and indicate the position and the kind of tools required.
2. Design a set of cams for a specific job to be done on a Brown and Sharpe screw machine. Provide a table of operations with throw, feed and revolutions for each operation.
3. Design a forming tool for a Brown and Sharpe screw machine.

Texts and References [1]

WILSON. *Tool Engineers Handbook*
BROWN AND SHARPE MANUFACTURING CO. *Automatic Screw Machines*
CALVIN AND HAAS. *Jigs and Fixtures*
COLE. *Tool Design*
DONALDSON AND LECAIN. *Tool Design*

[1] See Bibliography for publishers.

French and Vierck. *A Manual of Engineering Drawing for Students and Draftsmen*
Groehe. *Precision Measurement and Gaging Techniques*
Hinman. *Die Engineering Layouts and Formulas*
———. *Practical Design for Drilling, Milling, and Tapping Tools*
Hoover and Schumacher. *Tool and Die Drafting*
Jeffries. *Tool Design*
LeGrand. *The New American Machinists' Handbook*
New York State Vocational and Practical Arts Association. *Jigs and Fixture Design*
Oberg and Jones. *Machinery's Handbook.*
Rusinoff. *Tool Engineering*
St. Clair. *Design and Use of Cutting Tools*
Stanley. *Punches and Dies*
Wilson. *ASTME Die Design Handbook*

D 235, Design Problems

Hours Required

Class, 1; Laboratory, 9

Description

Opportunities in advanced drafting room practice are offered in this course. The student applies his knowledge of mathematics, science, and drawing to practical problems while he is designing complete machines or component parts of machines. He analyzes the problem, gathers data, sketches ideas on paper, does all necessary mathematical calculations, makes working drawings, and finally checks his work. Throughout the course he is encouraged to use his judgment and work on his own initiative.

Major Divisions

	Class hours	*Laboratory hours* [1]
I. Introduction	1	------
II. Design Considerations	1	------
III. Data Gathering	1	------
IV. Application of Mathematics to Design	1	------
V. Economy in Design	1	------
VI. Drafting Room Practices	1	------
VII. Design Projects	11	153

[1] Much of the lecture work deals with specific problems the students encounter in their design projects, particularly division VII. Students actually start their laboratory work at the beginning of the course.

I. Introduction
- A. Class—1 hour
  1. Classification of machines
  2. Design of a machine
     - a. Application of kinematics and machine design
     - b. Selection of materials
     - c. Determination of forces
     - d. Computations
     - e. Proportions of machine parts
     - f. Standard machine parts
     - g. Engineering drawing

II. Design Considerations
- A. Class—1 hour
  1. What is the machine to do?
  2. How is it to do it?
  3. Similar designs in use
  4. Specifications
  5. Moving and fixed parts
  6. Power source
  7. Space and weight
  8. Cost
  9. Strength
  10. Rigidity
  11. Lubrication
  12. Reliability
  13. Durability
  14. Safety
  15. Economy of operation
  16. Manufacturing
  17. Appearance
  18. Patent considerations
  19. Assembly
  20. Use of standard parts
  21. Use of interchangeable parts
  22. Servicing

III. Data Gathering
- A. Class—1 hour
  1. Output specifications
  2. Ideas obtained from similar designs
  3. Manufacturers' catalogues
  4. Handbooks
  5. Technical pamphlets and magazines
  6. Consultation with experts

IV. Application of Mathematics to Design
- A. Class—1 hour
  1. Algebraic equations
  2. Empirical formulas
  3. Tables
  4. Charts and graphs
  5. Mechanics
  6. Strength of materials
  7. Graphical solutions

V. Economy in Design
  A. Class—1 hour
    1. Material
    2. Weight
    3. Manufacturing
    4. Interchangeability of parts
    5. Complexity of design
    6. Special skills
    7. Special equipment
    8. Mass production
    9. Assembly
    10. Standard parts
    11. Shipment
    12. Modular size

VI. Drafting Room Practices
  A. Class—1 hour
    1. Idea sketching
    2. References
    3. Engineering layout
    4. Experimental models
    5. Detailing
    6. Checking
    7. Tooling
    8. Plan layout

VII. Design Projects
  A. Class—11 hours
    Discuss problems that arise during the designing of the various projects.
  B. Laboratory—153 hours
    Suggested Design Projects
    1. Tool Grinder—48 hours
       Design a bench grinder with two emery wheels to operate at a specified constant speed through a V-belt drive.
    2. Drill Press—54 hours
       Design a bench drill press to drill a specified maximum size hole. The drill must be able to run at different speeds. Use belt drive. The drill press should be designed to provide space and movement to comply with specifications. The drill is to be hand fed into the work.
    3. Speed Reducer—36 hours
       Design a speed reducer with a specified speed ratio and a given horsepower. Use either a pair of helical spur gears or a worm and worm gear. The unit is to be fully enclosed and splash lubricated.
    4. Punch Press—66 hours
       Design a belt-driven punch press to pierce a specified hole in a steel plate at a given rate of speed.
    5. Miscellaneous Design Projects
       Air cylinder
       Chain block
       Crane hoist
       Die
       Fixture
       Gasoline engine
       Hydraulic jack
       Jig
       Pump
       Screw jack
       Wood turning lathe
       Water turbine

Texts and References [1]

ALBERT. *Machine Design Drawing Problems*
BLACK. *Machine Design*
FRENCH and VIERCK. *Engineering Drawing*
KENT. *Mechanical Engineers' Handbook*
LEGRAND. *The New American Machinists' Handbook*
MARKS. *Mechanical Engineers' Handbook*
OBERG and JONES. *Machinery's Handbook*
SNOW and RUSSELL. *Machine Drafting*
TOZER and RISING. *Machine Drawing*
WINSTON. *Machine Design*

Manufacturers' catalogs and manuals.

[1] See Bibliography for publishers.

PRODUCTION OPTION

P 204, Methods and Operations Analysis

Hours Required

Class 3; Laboratory, 3

Description

Understanding of the techniques used in determining the best way of doing a specific piece of work is developed through the systematic study of methods, materials, tools and equipment for the purpose of finding the most economical way of doing the work, standardizing the methods and procedures to be followed, and determining the time required by an average worker to perform the various tasks.

Laboratory activities include the analysis of the fundamental physical motions, the construction of various charts, the practice of dividing operations into elements, and time study observations. Additional experience is gained in recognizing and giving value to foreign elements, allowances, and performance rating, and in calculating average cycle time, minimum observations, and standard times.

The techniques for making methods and operations analyses, as outlined in this course, are intended for the purpose of methods engineering, operations analysis, production scheduling and process flow chart preparation and not for the settling of jurisdictional matters or in the setting of wages or hours.*

*Because of the controversial nature of some of the topics included in this course outline, it is recommended that a special effort be made to obtain the latest authoritative information available for instructional purposes. In any study of methods and operations, especially where the work and pay of individuals are concerned, both the instructor and the student have a responsibility for complete objectivity.

Major Divisions

	Class hours	Laboratory hours
I. History of Methods Engineering	2	0
II. Process Charts	8	10
III. Operations Analysis	6	4
IV. Motion Study	4	4
V. Micromotion and Memomotion Study	2	2
VI. Predetermined Time Systems	6	6
VII. Factory Cost	2	0
VIII. Equipment used in Time Study	2	1
IX. Elements of Time Study	2	4
X. Performance Rating	4	4
XI. Allowances	2	2
XII. Standard or Allowed Time	2	2
XIII. Standard Data and Formulas	5	8
XIV. Work Sampling	2	4
XV. Wage Payment Plans	2	0

I. History of Methods Engineering
- A. Class—2 hours
  1. Introduction
     a. The production function
     b. Scope of methods engineering and time study
     c. Methods engineering
     d. Time study requirements
     e. Wage payment
  2. Development of Motion and Time Study
     a. Taylor and Gilbreth
     b. Motion study
     c. Early contemporaries
     d. Organizations
     e. Present trends
     f. Responsibility toward time
- B. Laboratory—0 hours

II. Process Charts
- A. Class—8 hours
  1. Introduction

2. Operation process chart
3. Flow process chart
4. Man and machine process chart
5. Gang process chart
6. Operator process chart

B. Laboratory—10 hours
1. Make an operation process chart.
2. Make a flow process chart.
3. Make a man and machine chart.
4. Make a gang process chart.

III. Operations Analysis

A. Class—6 hours
1. Introduction
2. Purpose of operation
3. Design of part
4. Tolerances and specifications
5. Material
6. Process of manufacture
7. Setup and tools
8. Working conditions
9. Material handling
10. Plant layout
11. Principles of motion economy

B. Laboratory—4 hours
1. Determine method of doing a specific job. Establish a proposed method.
2. Determine best method of doing a particular job in terms of quantity and quality. Consider tooling and labor costs.

IV. Motion Study

A. Class—4 hours
1. Fundamental motions (Therbligs)
2. Principles of motion economy
3. Theory of motion economy
4. Motion analysis as applied in planning

B. Laboratory—4 hours
1. Identify the fundamental motions in specific tasks and describe their function.
2. Construct an operation instruction card.

V. Micromotion and Memomotion Study

A. Class—2 hours
1. Introduction
   a. Preparation for a micromotion study
   b. Equipment
2. Motion pictures
   a. Analyzing the film
   b. Creating and improving method
   c. Teaching and standardizing the new method
3. Other motion study photographic techniques
   a. Memomotion study
   b. Cyclegraphic and chronocyclegraphic study

B. Laboratory—2 hours
Construct a simo-chart for a specific assembling operation.

VI. Predetermined Time Systems

A. Class—6 hours
1. Introduction
2. Definition
3. Predetermined time systems
   a. Work factor
   b. Methods—time-measurement
   c. Basic motion time study
   d. Motion—time analysis
   e. Dimensional motion times
4. Application

B. Laboratory—6 hours
Analyze specific operations in terms of the basic division of accomplishment and calculate the total cycle time by applying synthetic basic motion time values.

VII. Factory Cost

A. Class—2 hours
1. Introduction
2. Job analysis
3. Job evaluation
   a. Ranking method
   b. Classification method
   c. Factor comparison method
   d. Point system
4. Labor standards
5. Cost distribution

B. Laboratory—0 hours

VIII. Time Study Equipment

A. Class—2 hours
1. Necessary equipment
2. Auxiliary equipment
3. Special equipment
4. Forms

B. Laboratory—1 hour
Convert decimal minutes to decimal hours.

IX. Elements of Time Study

A. Class—2 hours
1. Analysis of materials and methods
2. Elemental breakdown

3. Types of studies
4. Taking the study
5. Rating
6. Allowances
7. Calculations—average cycle time, minimum cycles

B. Laboratory—4 hours
Practice dividing operations into elements based on time study observations of operation cycles. Record the time consumed by each element and difficulties encountered and calculate average cycle time and minimum number of cycle study requirements.

X. Performance Rating
A. Class—4 hours
1. Necessity of rating
2. Concept of normal
3. Principles of rating
4. Rating method
5. Analysis of rating
6. Training for rating

B. Laboratory—4 hours
1. Analyze time study data resulting from observations of different individuals performing the same task; compute the systematic error, mean deviation, absolute error for each person and for the group.
2. Analyze time study data and apply the more common techniques of performance rating such as skill and effort rating, objective rating, and synthetic rating.

XI. Allowances
A. Class—2 hours
1. Types
a. Personal
b. Fatigue
c. Delay
d. Machining
2. Application of allowances

B. Laboratory—2 hours
Using time study data on an operation, calculate the standard time after determining and applying personal, fatigue, delay, and machining allowances as they apply to each element.

XII. Standard or Allowed Time
A. Class—2 hours
1. Concept
2. Standard time
3. Types of standards
4. Maintenance of standards

B. Laboratory—2 hours
Using time study of an operation, evaluate the time study and then compare it with standard time data. Convert to decimal hour per hundred pieces and calculate operator efficiency.

XIII. Standard Data and Formulas
A. Class—5 hours
1. Direct work standards
a. Observation sheet
b. Spread or comparison sheet
c. Manual and machine elements
d. Constants
e. Variables
f. Development of standard data
g. Application of data
2. Indirect work standards
a. Need
b. Methods analysis
c. Types

B. Laboratory—8 hours
1. Develop standard times of constant and variable elements for various types of work and machines.
2. Make graphs, tables and monograms showing standard times for press working, foundry operations, and machining operations.

XIV. Work Sampling
A. Class—2 hours
1. Details
2. Application
3. Control chart
4. Technique

B. Laboratory—4 hours
1. Use the alignment chart to determine the number of observations required for a given degree of accuracy. Use the formula to check the accuracy of the alignment chart.
2. Conduct a simple work sampling project.

XV. Wage Payment Plans
  A. Class—2 hours
    1. Direct financial plans
    2. Indirect financial plans
    3. Nonfinancial plans
  B. Laboratory—0 hours

Texts and References [1]

AFL–CIO. *Wage Incentive Plans; Declines of Wage Incentives; Time Study; Job Evaluation Plans; Predetermined Time Systems in the U.S.A.*
AMERICAN SOCIETY OF TOOL ENGINEERS. *Tool Engineers Handbook*
BARNES. *Motion and Time Study*
CARSON. *Production Handbook*
CLOSE. *Work Improvement*
KRICK. *Methods Engineering*
LINCOLN. *Lincoln's Incentive Program*
LOWRY AND STEGEMERTEN. *Time and Motion Study*
MANDEL. *Motion and Time Study*
MAYNARD. *Industrial Engineering Handbook*
MAYNARD, STEGEMERTEN, and SCHWAB. *Methods–Time–Measurement*
NADLER. *Motion and Time Study*
NADWORNEY. *Scientific Management and the Unions*
NIEBEL. *Laboratory Manual for Motion and Time Study*
———. *Motion and Time Study*
STOCKER. *Materials Handling*

[1] See Bibliography for publishers.

P 234, Plant Layout and Materials Handling

Hours Required

Class 3; Laboratory 3

Description

Emphasis is placed upon the relationship between good plant layout and efficient materials handling. Evaluation of the site and planning of the factory building are done with consideration of transportation, shipping and receiving, power, heat, light, and air conditioning. Selection and arrangement of production machinery, product and process layout schemes, techniques of making layouts, and balance and flexibility of operations are fully discussed. Study is also made of the basic packaging and materials protection methods along with intensive consideration of the specific types of equipment used in the movement of incoming, in-process, storage, and waste materials.

The course centers upon the fundamental principles of materials handling and the factors affecting plant layout. These principles are therefore constantly referred to during laboratory activities which include developing the general overall layout, detailing each area, making scale models and arranging them, and drawing in the flow diagram for final evaluation.

Major Divisions

	Class hours	Laboratory hours
I. Introduction	2	0
II. Types of Plant Layouts	3	10
III. Factors Influencing Plant Layout	15	10
IV. Materials Handling	15	16
V. Planning the Layout	16	15

I. Introduction
- A. Class—2 hours
  1. Layouts of the past
  2. Purpose
  3. Nature of plant layout problems
- B. Laboratory—0 hours

II. Types of Plant Layouts
- A. Class—3 hours
  1. Elements of production
  2. The classic types
  3. Combination
  4. Economies of types
  5. Line production goal
- B. Laboratory—10 hours
  1. Construct a table showing the possible combinations of the elements of production and give descriptive examples of each.
  2. Make a layout of a work area showing the principle of layout-by-fixed-position.
  3. Make a layout of a work area showing the principle of layout-by-process.
  4. Make a layout of a work area showing the principle of layout-by-product.

III. Factors Influencing Plant Layout
- A. Class—15 hours
  1. Material
  2. Machinery, tools, and equipment
  3. Man
  4. Movement
  5. Waiting
  6. Service
  7. Building
  8. Change
  9. Zoning
  10. Process requirements
  11. Safety
      - a. Men
      - b. Materials
- B. Laboratory—10 hours
  1. Take inventory of equipment and machinery of a typical shop and calculate the required floor area.
  2. Construct multiproduct flow-process chart.

IV. Materials Handling
- A. Class—15 hours
  1. Basic principles
  2. Methods analysis

3. Types of movements
4. Classification and types of equipment
   a. Comparison
   b. Handling times
5. Packaging methods and materials
   a. Domestic
   b. Foreign
6. Storage facilities
7. Handling costs

B. Laboratory—16 hours
1. Draw floor plan and arrange machinery and equipment to conform to the "layout-by-process" type. Draw in flow diagram, show inspection areas, and list types of handling equipment.
2. Make a floor plan for a given number of stations and operations using the production-by-product principle. Show material flow, necessary handling equipment, and inspection stations.

V. Planning the Layout.

A. Class—16 hours
1. Guiding fundamentals
2. Planning approach
3. Obtaining the facts
4. Determining the flow
5. Diagramming the flow
6. Measuring time involved
7. Visualizing the layout
8. Comparing with alternate layouts
9. Presenting the layout
10. Installing the layout
11. Relationship of quality to type of layout
12. Layout improvements

B. Laboratory—15 hours
1. Make a plant layout for complete processing of a product made up of several in-plant-processed and outside-purchased components.
2. Make a list of machinery and equipment requirements and arrange them in the order of the processes determined in assignment 1.

Texts and References [1]

AMERICAN SOCIETY OF TOOL ENGINEERS. *Tool Engineers Handbook*

HAYNES. *Materials Handling Equipment*

IMMER. *Layout Planning Techniques*

———. *Materials Handling*

IRESON and GRANT. *Handbook of Industrial Engineering and Management*

MALLICK and GAUDREU. *Plant Layout Planning and Practice*

MAYNARD. *Industrial Engineering Handbook*

MOORE. *Plant Layout and Design*

MUTHER. *Practical Plant Layout*

REED. *Plant Layout*

STOCKER. *Materials Handling*

[1] See Bibliography for publishers.

P 244, Process Planning

Hours Required

Class 3; Laboratory 3

Description

A comprehensive study of the fundamental principles, practices, and methods of process planning. The responsibilities and range of activities normally associated with process planning are surveyed; also the relationship of process planning to other manufacturing functions.

The course is made more meaningful by constant reference to concrete examples, interpretation of charts, operation analysis, and routing forms. Student participation is provided through selected case problems having single or multiple solutions. Additional classroom activities include the actual process planning of selected jobs in terms of description and the sequence of operations, tolling determination, setup time estimating, feed and speed calculations, process and machinery selection.

Major Divisions

	Class hours	Laboratory hours
I. Process Planning Function	3	9
II. Process and Operation Selection	9	9
III. Designing for Manufacture	5	9
IV. Equipment Planning and Tooling Selection	9	9
V. Process Planning the Job	13	15
VI. Case Problems	12	0

I. Process Planning Function
- A. Class—3 hours
  1. Development of process engineering
     a. Introduction
     b. Qualification
     c. Preliminary requisites for processing
  2. Tools of the process engineer
     a. Analysis sheet (methods)
     b. Machine capability chart
     c. Machine and tool availability chart
     d. Process chart

  3. Processing procedure
     a. Identification
     b. Activities defined
     c. Operation sequence
- B. Laboratory—9 hours
  1. Plan the operations of a process.
  2. Construct process chart.
  3. Establish feeds and speeds.

II. Process and Operation Selection
- A. Class—9 hours
  1. Types of processes
  2. Operation of a process
     a. Source of materials
     b. Enterprise protection
     c. Critical operations (locating points or surfaces)
     d. Placement operations (nondimensional)
     e. Tie operations (supporting)
     f. Assembly operations
  3. Contents of a process plan
     a. Identification of purpose
     b. Designation of area
     c. Specifications of methods
     d. Specification of quality and tooling
     e. Specification of performance
     f. Quantity requirement
  4. Use of process chart
     a. Types
     b. Construction
- B. Laboratory—9 hours
  Plan the operations of two or more processes requiring the use of the basic machine tools.

III. Designing for Manufacture
- A. Class—5 hours
  1. Product design
     a. Definition
     b. Prime concept
     c. Benefits
     d. Organization
  2. Economics in product design
     a. Factors affecting costs
     b. Calculating worth of design

c. Evaluating a design proposal
d. Improving the design
e. Material selection

B. Laboratory—9 hours
1. Analyze product designs.
2. Plan the operations of three processes.
3. Establish cycle times.
4. Determine machine types and capacities.

IV. Equipment Planning and Tooling Selection

A. Class—9 hours
1. Types of equipment
2. Replacement of machinery and equipment
a. Need for replacement
b. Basic problems
c. Pattern for replacement studies
d. Selection of machines and equipment
3. Production line techniques
a. Underlying principles
b. How to plan
c. Methods of balance
4. Tooling selection
a. Types and classifications
b. Principles of dimensioning
c. Workpiece location
d. Workpiece clamping
e. Operation tolerance
f. Stock allowances

B. Laboratory—9 hours
1. Plan the operations of a process using the principle of multiple tooling and combined and simultaneous operations to be performed on a turret lathe, hand screw machine or automatic screw machine.
2. Determine tooling requirements.

V. Process Planning the Job

A. Class—13 hours
1. Methods of approach
a. The basic questions
b. Action expected
c. Flow process chart
2. Determining the operations
a. Machine availability
b. Tolerances
c. Material
d. Surface finish
e. Number of passes or stations
3. Establishing sequence of operations
a. Reference surface
b. Commercial shapes
c. Natural sequence
d. Interference
4. The flow diagram
5. The operation analysis sheet
a. Identification
b. Operations
c. Setup
d. Tools and equipment
e. Working conditions
f. Details of analysis

B. Laboratory—15 hours
1. Plan the operations of several processes involving several component parts of different materials, the selected product for processing to be such that it requires punch press, foundry, welding, machining and assembling operations.
2. Prepare master process sheets for each component.

VI. Case Problems

A. Class—12 hours
1. Product development
a. A new machine tool
b. A new product
2. Machinery
a. Replacement policy
b. Rebuilding program
c. Preventive maintenance
3. Materials
a. Purchase department
b. Selection of sources
c. Decision to make or buy
d. Mechanical handling
4. Process improvement
a. Workplace arrangement
b. Balancing assembly line
c. Man-machine utilization

B. Laboratory—0 hours

Texts and References[1]

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. *Metals Engineering—Processes.*
AMERICAN SOCIETY OF TOOL ENGINEERS. *Tool Engineers Handbook.*
ANDERSON and BANCROFT. *Statistical Theory in Research*
BOWKER and LIEBERMAN. *Handbook of Industrial Statistics.*

[1] See Bibliography for publishers.

FELLER. *An Introduction to Probability Theory and Its Application*
FREEMAN. *Industrial Statistics*
HOEL. *Introduction to Mathematical Statistics*
HOLDEN and SHALLENBERGER. *Selected Case Problems in Industrial Management*
IRESON and GRANT. *Handbook of Industrial Engineering and Management*
MAYNARD. *Industrial Engineering Handbook*
MOOD. *Introduction to the Theory of Statistics*
WAUGH. *Elements of Statistical Method*
WILKS. *Elementary Statistical Analysis*

P 254, Production Problems

Hours Required

Class 1; Laboratory 9

Description

A detailed study is made of various production activities and the problems associated with them. Problems and cases are solved through the use of available data in texts and engineering handbooks. Discussion of each topic begins with a consideration of the nature of the problem and continues with a presentation of the detailed approach to be employed in its solution. Some problems deal with the analysis of the elements of production scheduling. Others deal with methods of determining production costs in terms of labor, material, and burden. Balancing work stations on production lines by graphic, as well as by mathematical means to achieve constant flow and calculating machine capacities to establish completion dates, represent a major portion of the laboratory work. Simulated industrial office atmosphere permits student groups representing various departments and functions of production to work cooperatively to achieve common objectives. Constant use of blueprints throughout the course strengthens the ability of the student to visualize and to interpret them.

Major Divisions

	Class hours	Laboratory hours
I. Cost Estimating Methods	3	6
II. Cost Estimating Elements	3	45
III. Production Activities	3	27
IV. Quantitative Analysis	8	75

I. Cost Estimating Methods
- A. Class—3 hours
  1. Introduction
  2. Estimating requirements
  3. General methods
     - a. Weights, sizes and commercial shapes
     - b. Tool costs and tool life
  4. The detail method
  5. The basic time study method
  6. The ratio method
  7. Estimating forms
- B. Laboratory—6 hours
  1. Determine shape weights of forgings and castings.
  2. Determine cut weights, bar weights, and consumed weights of fabricated materials.

II. Cost Estimating Elements
- A. Class—3 hours
  1. Use of graphs and tables
  2. Preparation time (setup)
  3. Tool maintenance
  4. Performance time
  5. Personal allowances
  6. Process loss allowances
  7. Number of operations and passes
  8. Sequence of operations
  9. Quality requirements
  10. Materials
  11. Labor and burden rates
  12. Departmental costs
  13. Difficulty factors
- B. Laboratory—45 hours
  1. Determine machining times, setup times, and handling times for various specified jobs.
  2. Construct feed, speed, and rpm charts and graphs.
  3. Calculate the total cost of manufacturing specified items in given quantities in terms of applicable factors.

III. Production Activities
- A. Class—3 hours
  1. Scheduling
  2. Machine loading
  3. Design changes
  4. Methods improvement
  5. Inventory
  6. Work areas
  7. Work hazards
  8. Scrap and salvage

9. Processing
10. Balancing production lines

B. Laboratory—27 hours
1. Schedule for production specified jobs in quantity having several component parts and given target dates. Consider material in stock, lead time, scrap ratio, processing techniques, machine loads, and possible change in design to reduce and simplify operations.
2. Solve problems in production line balancing by equating time standards, number of personnel, combining and eliminating operations, reducing elemental times, changing feeds and speeds, and introducing special purpose machines.

IV. Quantitative Analysis

A. Class—8 hours
1. Operation research
   a. Place in industry
   b. Cost
   c. Application
      (1) Quening theory
      (2) The model
      (3) Optimum distribution of effort
      (4) Appraisal
2. Linear programming
   a. Index method
   b. The modified distribution method
   c. Simplex method (introduction)
3. Economic order quantity
   a. Computing standard order quantity
   b. Economic order quantity formula
   c. To make vs. to buy
   d. ABC analysis

B. Laboratory—75 hours
1. Solve order problems, using the index method in which several orders are programmed on a given number of machines, and have specified standard times for each piece and machine hours available.
2. Solve problems in linear programming, using the modified distribution method, with specific order loads, available machine times, standard pieces per hour, and cost per piece.
3. Estimate engineering, founding, forging, stamping, machining, assembling, packaging, and shipping costs and set up production scheduling for a typical industrial product.

Texts and References [1]

AMERICAN SOCIETY OF TOOL ENGINEERS. *Tool Engineers Handbook.*
HENRICI. *Standard Costs for Manufacturing.*
KOEPKE. *Plant Production Control.*
MAYNARD. *Industrial Engineering Handbook.*
MILES. *Techniques of Value Analysis and Engineering.*
NORDOFF. *Machine Shop Estimating.*
SCHEELE. *Principles and Design of Production Control Systems.*
THUESEN. *Engineering Economy.*
VORIS. *Production Control.*

[1] See Bibliography for publishers.

MATHEMATICS AND SCIENCE

M 115, Mathematics I

Hours Required

Class, 5; Laboratory, 0

Description

The choice of topics and the order in which they are presented integrate mathematics with the technical courses in the curriculum to their mutual benefit. Thus the basic slide rule operations are introduced early in the course so that the student can use this tool to advantage in other courses. As the various topics are introduced the meaning and underlying principles of each and the role each plays in mechanical technology should be considered before the subject proper is explored. Practical problems following the exposition of each major topic will help to motivate the student and will strengthen his understanding of the principles involved.

Prerequisites: One year each of high school algebra and geometry.

Major Divisions

	Class hours
I. Arithmetic Review	3
II. Basic Slide Rule	3
III. Fundamental Algebraic Operations	7
IV. Equations and Formulas	12
V. Applied Problems in Plane and Solid Mensuration	6
VI. Introduction to Analytic Geometry and Graphing	8
VII. Simultaneous Equations	8
VIII. Exponents, Radicals, and Complex Numbers	8
IX. Quadratic Equations in One Unknown	7
X. Ratio, Proportion, Variation	3
XI. Logarithms	10
XII. Introduction to Trigonometry	10

I. Arithmetic Review—3 hours
   1. Number systems
      a. Decimal
      b. Binary
   2. Fundamental Operations
      a. Integers
      b. Fractions
      c. Decimals
      d. Changing fractions to decimals
   3. Percentage

II. Basic Slide Rule—3 hours
   1. Types of slide rules and calculators
   2. Multiplication and division
   3. Powers of ten
   4. Combined multiplication and division
   5. Squaring and square root

III. Fundamental Algebraic Operations—7 hours
   1. Positive and negative numbers
   2. Review of addition, subtraction, multiplication, and division
   3. Review of factoring
   4. Review of fractions

IV. Equations and Formulas—12 hours
   1. Meaning and underlying principles of equations
   2. Solving first degree equations in one unknown
   3. Formula rearrangement and evaluation
   4. Significant figures and approximate computation

V. Applied Problems in Plane and Solid Mensuration—6 hours
   1. Area and volume of common figures and solids
   2. Relations in triangle, quadrilateral, and circle
   3. Applied problems in geometry

VI. Introduction to Analytic Geometry and Graphing—8 hours
   1. Rectangular coordinate system
   2. Meaning of function in mathematics
   3. Graphing a function
   4. Graphing technical data

5. Equation of the straight line
6. Concept of slope

VII. Simultaneous Equations—8 hours
1. Linear equations in two unknowns
2. Linear systems in three unknowns
3. Solution by determinants
4. Illustrative practice technical problems

VIII. Exponents, Radicals, and Complex Numbers—8 hours
1. Review of law of exponents
2. Relationship between fractional exponents and radicals
3. Meaning of the complex number
4. Basic operations with complex numbers

IX. Quadratic Equations in One Unknown—7 hours.
1. Standard form $ax^2+bx+c=0$
2. Formula solution—completing the square
3. Solution by factoring
4. Graphical solution
5. Applied problems

X. Ratio, Proportion, Variation—3 hours
1. Meaning of ratio and proportion
2. Slide rule solution of proportion problems
3. Meaning of direct, inverse, and inverse square variation
4. Technical use of these concepts

XI. Logarithms—10 hours
1. Logarithmic meaning and notation
2. Relation between logarithmic and exponential form
3. Laws of logarithms
4. Tables of logarithms
5. Computation: products, quotients, powers, roots
6. Solution and rearranging of exponential and logarithmic equations
7. Natural logarithms
8. Logarithmic scale: slide rule graphing

XII. Introduction to Trigonometry—10 hours
1. Purpose of trigonometry
2. Definitions of six functions of an acute angle
3. Trigonometric tables
4. Solution of right triangles
5. Applied problems in right triangles

Texts and References [1]

ANDRES, MISER, and REINGOLD. *Basic Mathematics for Science and Engineering*

CHEMICAL RUBBER PUBLISHING COMPANY. *C. R. C. Standard Mathematics Tables*

CORRINGTON. *Applied Mathematics for Technical Students*

ELLIOTT and MILES. *College Mathematics, A First Course*

HEMMERLING. *Mathematical Analysis*

PERSON. *Essentials of Mathematics*

RASSWEILER AND HARRIS. *Mathematics and Measurement*

RICE AND KNIGHT. *Technical Mathematics with Calculus*

TUITES. *Basic Mathematics for Technical Courses*

THIES. *Industrial Mathematics*

VANVOORHIS AND HASKINS. *Basic Mathematics for Engineering and Science*

Visual Aids

Knowledge Builders, Visual Education Center Building, Floral Park, N.Y.:
Areas
Circle
Ratio and Proportion

United World Films, Inc., 1445 Park Avenue, New York 29:
Slide Rule: Multiplication and Division
Slide Rule: Percentage, Proportion, Squares and Square Roots

Demonstration slide rule.

Models and mockups illustrating some practical uses of mathematics in the solution of problems in mechanical technology.

[1] See Bibliography for publishers.

M 144, Mathematics II

Hours Required

Class, 4; Laboratory, O

Description

Trigonometry, analytic geometry, and algebra are continued and expanded to more advanced phases as required in the technology. Graphical analysis is used wherever possible. Practical problems in all major topics illustrate the principles involved and the utility of mathematics in technical study. Calculus is incorporated in a manner emphasizing concept and principle rather than facility in manipulation.

Prerequisite: M 115, Mathematics I

Major Divisions

		Class hours
I.	Solution of Right Triangles	8
II.	Trigonometric Functions for Any Angle	4
III.	Solution of Oblique Triangles	6
IV.	Solution of Triangles: Applied Problems	3
V.	Trigonometric Identities and Equations	3
VI.	Trigonometric Graphing	5
VII.	Complex Numbers and Vectors	8
VIII.	Sequences and Series	3
IX.	Analytic Geometry	8
X.	Higher Deg:ee Equations	4
XI.	Introduction to Calculus	9
XII.	Graphic Calculus	7

I. Solution of Right Triangles—8 hours
1. Definitions of trigonometric functions
2. Trigonometric ratios in triangle solution
3. Slide rule in computation
4. Logarithms in computation

II. Trigonometric Functions for Any Angle—4 hours
1. Generalized definition of six functions
2. Graphs of functions: sine, cosine, tangent
3. Numerical values of functions
4. Radian system of measurement

III. Solution of Oblique Triangles—6 hours
1. Right triangle method and scaling
2. Sine law method
3. Cosine law method
4. Further methods: tangent and half-angle laws

IV. Solution of Triangles: Applied Problems—3 hours
1. Review solution of triangles: right and oblique
2. Simple vector problems
3. Problems from technology

V. Trigonometric Identities and Equations—3 hours
1. Identities vs. conditional equations
2. Reciprocal, ratio, and Pythagorean identities
3. Two-angle, half-angle, and double-angle identities
4. Proofs of identities
5. Solving conditional trigonometric equations

VI. Trigonometric Graphing—5 hours
1. Review of sine, cosine, and tangent graphs
2. General sine equation: $y=K \sin (x+0)$
3. Sine wave generation by rotation
4. Sine wave harmonics and harmonic addition
5. Lissajous figures

VII. Complex Numbers and Vectors—8 hours
1. Meaning and basic operations of complex numbers
2. Graphical representation of complex numbers
3. Vector addition and multiplication
4. Vector subtraction and division

VIII. Sequences and Series—3 hours
1. Sequences and series in applied mathematics
2. Arithmetic progression

3. Geometric progression
4. Infinite series: convergent and divergent
5. Sine x, cosine x, e^x, and log x series

IX. Analytic Geometry—8 hours
1. Simple graphs and properties: circle, ellipse, parabola, and hyperbola
2. Graphical solution of simultaneous quadratic equations
3. Polar coordinate loci
4. Exponential functions

X. Higher Degree Equations—4 hours
1. Polynomial equations in one unknown
2. Review solution of linear and quadratic equations
3. Solution of cubic equations by approximation
4. Number and nature of roots of higher degree equation

XI. Introduction to Calculus—9 hours
1. Calculus and technical work
2. Rate of change
3. Graphical determination of rate of change
4. Review of function concept

XII. Graphic Calculus—7 hours
1. Graphic integration
   a. Increments by blocks
   b. Ray method of integration
   c. Plotting the integral
2. Graphic differentiation
   a. Graphic methods
   b. Applied problems

Texts and References [1]

ANDRES, MISER, and HASKINS. *Basic Mathematics for Engineering and Science.*
CHEMICAL RUBBER PUBLISHING CO., *C.R.C. Standard Mathematics Tables.*
CORRINGTON. *Applied Mathematics for Technical Students.*
ELLIOT and MILES. *College Mathematics, A First Course.*
HEMMERLING. *Mathematical Analysis.*
PERSON. *Essentials of Mathematics.*
RASSWEILER and HARRIS. *Mathematics and Measurement.*
RICE and KNIGHT. *Technical Mathematics with Calculus.*
TUITES. *Basic Mathematics for Technical Courses.*
VANVOORHIS and HASKINS. *Basic Mathematics for Engineering and Science.*

Visual Aids

Knowledge Builders, Visual Education Center Building, Floral Park, N.Y.:
Congruent Figures
Pythagorean Theorem

United World Films, Inc., 1445 Park Avenue, N.Y.:
Introduction to Vectors: Co-Planar, Concurrent Forces
Periodic Functions

Johnson Hunt Productions, 1104 Fair Oaks Avenue, South Pasadena, Calif.:
Parallel Lines.

Demonstration slide rule.

Models and mockups illustrating practical uses of mathematics in the solution of problems in mechanical technology.

[1] See Bibliography for publishers.

S 145, Mechanics and Heat

Hours Required

Class, 4; Laboratory 2

Description

The objectives of this course extend beyond its immediate purpose of developing an understanding of the basic principles of mechanics and heat. Not apparent in the outline but of crucial importance is the emphasis in both laboratory and lecture upon the scientific method. Heavy reliance is placed upon material from mathematics courses and the use of the slide rule in computation of data in the laboratory.

Prerequisite: M 144 Mathematics or concurrent registration in M 144.

Major Divisions

	Class hours	Laboratory hours
I. Basic Measurement	6	4
II. Properties of Solids, Liquids, and Gases	10	2
III. Statics	15	10
IV. Rectilinear Motion and Momentum	5	4
V. Angular and Simple Harmonic Motions	6	4
VI. Work, Energy, and Power	8	4
VII. Heat and Temperature	10	4
VIII. Thermodynamics	8	2

I. Basic Measurement
- A. Class—6 hours
  1. Science and measurement: units of measurement
     - a. The scientific method and measurement
     - b. Systems of measurement
       - (1) Traditional: metric and English
       - (2) Modern: cosmic, atomic, industrial
  2. Methods of measurement
     - a. United States standards
     - b. Aids to measurement—vernier, micrometer, planimeter, optical flats, comparators, diffraction grating
- B. Laboratory—4 hours
  1. Use vernier and micrometer calipers, planimeter, spherometer in measurement.
  2. Become familiar with the use of optical flats, comparators, and diffraction gratings in measurement.

II. Properties of Solids, Liquids, and Gases
- A. Class—10 hours
  1. Structure of matter
     - a. Atoms—the periodic table
     - b. Elements, compounds, crystals
  2. Elasticity and rigidity
     - a. Units of measure: Young's modulus, torsion
     - b. Deformation—stress, strain, fatigue
     - c. Hooke's Law
  3. Hydrostatics—properties of fluids
     - a. Density, specific gravity, buoyancy
     - b. Statement and application of Pascal's and Archimede's Law
     - c. Bernoulli's theorem and applications
     - d. Phenomena of viscosity, capillarity, surface tension
     - e. Orifice: pressure, flow, loss of head
  4. Properties of gases
     - a. Bernoulli's theorem
     - b. Measurement of pressure
- B. Laboratory—2 hours
  1. Calculate the densities of solids and liquids.
  2. Determine the elastic properties of materials and become familiar with their specifications and limitations.
  3. Determine the deflection of a beam with varying loads and dimensions.
  4. Compute the modulus of rigidity of a rod.
  5. Measure buoyancy of liquids.

III. Statics
- A. Class—15 hours
  1. Composition of resolution of vectors
     - a. Definition of vector—examples
     - b. Components and composition
     - c. Resolution of vectors
     - d. Methods of handling
       - (1) Graphical
       - (2) Analytical: summation, trigonometry
  2. Conditions of equilibrium
     - a. Forces and vector diagrams
     - b. Principle of transmissibility
  3. Statics of structures: cranes, trusses
  4. Friction—coefficient of friction
  5. Principle of moments
  6. Application of moments to members of structures
- B. Laboratory—10 hours
  1. Convert a system of concurrent forces into a vector diagram.
  2. Solve problems from mechanical technology using vectors—machine and structure design.
  3. Analyze a system of forces: the crane.
     - a. Designate resultant and equilibrant.
     - b. Confirm graphical solution of computation.
  4. Determine the coefficient of friction between simple objects.
  5. Determine the center of gravity of a series of forces and the reaction at supports of parallel forces.
  6. Calculate internal and external moments in members of a structure.

IV. Rectilinear Motion and Momentum
- A. Class—5 hours
  1. Rectilinear motion—displacement and rates of change
  2. Systems of units—C.G.S., English, M.K.S.
  3. Newton's second law
  4. Law of universal gravitation—free fall, spatial problems
  5. Inertia of a body
  6. Physical aspects of momentum
     - a. Transmission: impulse, impact, collision
     - b. Units and denominations
     - c. Jet propulsion principles
  7. Motion of a projectile
- B. Laboratory—4 hours
  1. Set up and operate equipment for measuring all characteristics of rectilinear motion.
     - a. Calibrate timing unit.
     - b. Specify displacement.
     - c. Determine velocities and accelerations.
     - d. Graph motion and extrapolate values.
  2. Apply Newton's second law to forces in cables and hoists.
  3. Calculate the inertia of a body.
  4. Specify and measure the characteristics of the motion of a projectile and free fall object.
  5. Measure one momentum of a body: ballistic pendulum.

V. Angular and Simple Harmonic Motions
- A. Class—6 hours
  1. Forces on bodies in motion
  2. Circular motion: formulas and denominations
  3. Centrifugal action
     - a. Vectors and components
     - b. Applications in centrifuge, satellites, highways, castings
  4. Harmonic motion
     - a. Characteristics: amplitude, displacement, frequency, period
     - b. Equations and graphs
     - c. Types: simple and compound pendulums, spring, electronic
     - d. Vibration in structures
  5. Gyroscopic action
- B. Laboratory—4 hours
  1. Confirm the laws of centripetal force; centrifuge.
  2. Investigate simple harmonic motion: the simple pendulum, compound and torsion pendulum.
  3. Confirm the rules of gyroscopic action.

VI. Work, Energy, and Power
- A. Class—8 hours
  1. Physical concept of work
     - a. Forces, directions, distances, and units
     - b. Positive and negative character of work and energy
  2. Energy and its manifestations
  3. Conservation of energy
  4. Power as compared to work and energy

5. Simple machines: inclined plane, pulleys, belts, and gears
    a. Aspects of work, energy, power, and efficiency
    b. Mechanical advantage
    c. Friction in machines
    d. Power transmission

B. Laboratory—4 hours
1. Calculate the mechanical advantage and efficiency of inclined planes, pulleys, and gears.
2. Relate work, energy, and power in simple machines.
3. Confirm conservation of energy in simple machines.

VII. Heat and Temperature

A. Class—10 hours
1. Heat energy
    a. Quantity and intensity—units of measure
    b. Specific heat
    c. Thermal properties of materials: heats of combustion, fusion, vaporization
    d. Methods of calorimetry: heat balance, heat-added, and given-off methods
    e. Combustion, economy aspects of various fuels
2. Temperature
    a. Methods of thermometry
    b. Temperature scales
    c. Coefficients of expansion
    d. Applications of expansion and contraction
    e. Temperatures encountered in industry
    f. Interpretation of absolute zero
    g. Low temperature properties of materials
3. Transfer of heat
    a. Conduction, convection, radiation
    b. Heat flow formulas and constants
    c. Newton's law of cooling
    d. Thermal insulation
    e. Practical aspects of heat transfer

B. Laboratory—4 hours
1. Confirm Charles' Law using the constant volume air thermometer.
2. Calculate the coefficient of linear expansion of various materials.
3. Determine the specific heat of various metals.
4. Measure the heats of fusion and vaporization of a substance.
5. Confirm Newton's Law of cooling.
6. Measure absolute and relative humidity.
7. Determine the mechanical equivalent of heat.

VIII. Thermodynamics

A. Class—8 hours
1. Gas laws
    a. Boyle's and Gay-Lussac's laws
    b. Ideal gas equation
    c. Adiabatic expansion and compression
2. First law of thermodynamics
    a. Relationship between heat and work
    b. Industrial applications
3. Second law of thermodynamics
    a. Efficiency in heat conversion to work
    b. Heat engine cycles: Carnot, Rankine, Diesel, Otto
    c. The reversed cycle

B. Laboratory—2 hours
1. Measure absolute and relative humidity and relate these to industrial problems.
2. Determine the mechanical equivalent of heat.
3. Confirm Boyle's Law.

Texts and References [1]

Block and Little. *An Introductory Course in College Physics*
Condon (ed.). *Handbook of Physics*
Frank. *Introduction to Mechanics and Heat.*
Furry, Purcell and Street. *Physics for Science*
Halliday and Resnick. *Physics for Students of Science and Engineering, Part I*
Harris and Hemmerling. *Introductory Applied Physics*
Key. *Elementary Engineering Mechanics*
Marin and Sauer. *Strength of Materials*
National Science Foundation. *American Institute of Physics Handbook*
Orear. *Fundamental Physics*
Sears and Zemansky. *College Physics, Part II,* 3d Ed.
Smith and Cooper. *Elements of Physics*
Stearns. *Fundamentals of Physics and Applications*
Weber, White and Manning. *Physics for Science and Engineering*

[1] See Bibliography for publishers.

Visual Aids

Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill.:
Galileo's Laws of Falling Bodies
Gas Laws and Their Application
Heat—Its Nature and Transfer
Laws of Motion
Simple Machines
Thermo-dynamics

McGraw-Hill Book Co., Inc., 330 West 42d Street, New York 36, N.Y.:
Carnot Cycle and Kelvin Scale
Diesel Engine
Gasoline Engine
Uniform Circular Motion

United World Films, Inc., 1445 Park Ave., New York 29, N.Y.:
Basic Hydraulics
Electron—An Introduction
Principles of Dry Friction
Principles of Moments
Principles of Refrigeration
Verniers

S 214, Electricity

Hours Required

Class 3; Laboratory 2

Description

This is an introduction to electrical circuitry and equipment with emphasis on the concepts of electrical physics. The treatment of this subject as a mathematics-based science provides a basis for further study for those students who will require a greater depth of understanding in this area.

Prerequisite: Mathematics I and II

Major Divisions

	Class hours	Laboratory hours
I. Electricity and Magnetism	3	2
II. Basic Electric Circuits and Components	15	10
III. Alternating Currents	9	6
IV. Electric Power	6	4
V. Basic Electronics	3	2
VI. Motors and Controls	15	10

I. Electricity and Magnetism
- A. Class—3 hours
  1. Nature of electricity—the electron theory
     - a. Atomic structure—historical development
     - b. Conductors—specific resistance
     - c. Insulators—dielectric strength
  2. Electrical units
     - a. Coulomb—static electricity
     - b. Ampere—current electricity
     - c. Volts, ohms, watts
  3. Nature of magnetism
     - a. Atomic theory of magnetism
     - b. Permanent and electromagnets
     - c. Law of magnets and magnetic field strengths
     - d. Hysteresis curve: permeability, retentivity, saturation
     - e. Applications of magnets
- B. Laboratory—2 hours
  1. Verify the laws of electrostatics and electrostatic induction; sketch electrostatic fields.
  2. Confirm the law of magnets and sketch magnetic fields using permanent and electromagnets.

II. Basic Electric Circuits and Components
- A. Class—15 hours
  1. Ohm's Law in D.C. series resistance circuits
  2. Ohm's Law in D.C. parallel resistance circuits
  3. Measurement of resistance: volt-ammeter, Wheatstone bridge, ohmmeter
  4. Inductance in D.C. circuits
     - a. Electromagnetic induction—Lenz's law
     - b. Concept and units of self-inductance
     - c. Rise and decay of current in an inductance
     - d. Energy in inductive circuits
     - e. Mutual inductance—coefficient of coupling
     - f. Series and parallel inductances
  5. Capacitance in D.C. circuits
     - a. Definition and units of capacitance
     - b. Rise and decay of voltage in a capacitor
     - c. Energy in capacitive circuits
     - d. Series and parallel capacitors
- B. Laboratory—10 hours
  1. Problems in series and parallel resistive D.C. circuits.
  2. Measure direct current in series, parallel, and combination circuits.
  3. Plot the rise and decay of voltage across a capacitor in an R-C circuit. Calculate time constant.

III. Alternating Currents
- A. Class—9 hours
  1. Electromagnetic generation of a sine wave

2. Sine wave terminology and vector representation
3. Inductive and capacitive reactance
   a. Definition and units of measure
   b. Vector representation—phase angle
   c. Impedance—vector diagrams
   d. Resonance—vector diagrams
4. A.C. circuits in resistance, capacitance, and inductance
5. Measurement of alternating current
6. The electromagnetic spectrum—high frequencies
7. Electromechanical analogies
   a. Resistance—friction; power consumption
   b. Inductance—inertia; kinetic energy
   c. Capacitance—potential energy
8. A.C. Alternators and transformers

B. Laboratory—6 hours
1. Electromagnetic generation and transmission equipment.
2. Demonstrate and calculate A.C. circuit constants using vector analysis.

IV. Electric Power

A. Class—6 hours
1. Sources of electric power
   a. Electromagnetic generators and alternators
   b. Chemical action—primary and secondary cells
   c. Thermo- and photo-electricity
2. Power in D.C. and A.C. circuits
3. Production and distribution of commercial electrical power
   a. The generating station—energy conversion
   b. The transformer
   c. Transmission lines: voltage vs. losses
   d. Comparison between D.C. and A.C. systems
4. Consumption of electric power
   a. Heat and light; principles of common devices
   b. Motors: principles of series and shunt motors
   c. Chemical uses; electroplating, electrolysis

B. Laboratory—4 hours
1. Measure power in direct and alternating current circuits.
2. Make field trip to power generating and distributing installations.
3. Demonstrate conventional and unconventional power sources.

V. Basic Electronics.

A. Class—3 hours
1. Controlling electric current: historical development; rheostat, vacuum tube, transistor
2. The diode tube
   a. Thermionic emission
   b. Characteristic curves
   c. Rectification; principles and use
3. The triode tube
   a. Grid control—electrostatic fields
   b. Characteristic curves
   c. Concept of amplification
   d. Applications
4. Solid state devices
   a. Sophistication of solid state conduction
   b. Mechanism of conduction in semiconductors
5. Applications of electronics
   a. Communications
   b. Industrial processing and control

B. Laboratory—2 hours
1. Measure the characteristics of a diode and observe its action as a rectifier on an oscilloscope.
2. Measure and calculate the amplification factor of a triode tube.
3. Demonstrate electronic control equipment.

VI. Motors and Controls

A. Class—15 hours
1. Operating characteristics of direct current motors
   a. Shunt
   b. Series
   c. Compound
2. Direct current motor controllers
3. A.C. motor types and characteristics
4. Control and protection of A.C. equipment
5. Special applications of A.C. devices
   a. Relays
   b. Thyratrons
   c. Servos

B. Laboratory—10 hours
   1. Demonstrate motors and motor control equipment.
   2. Measure speed-load and torque characteristics of D.C. and A.C. motors.
   3. Make field trip to industrial installations.
   4. Demonstrate industrial control equipment.
      a. Spot welders
      b. Induction heating units
      c. Instrumentation

Texts and References [1]

BLACK and LITTLE. *An Introductory Course in College Physics*, 4th ed.

FURRY, PURCELL, and STREET. *Physics for Science and Engineering Students*

GILLIE. *Electrical Principles of Electronics*

GROB. *Basic Electronics*

HARRIS and HEMMERLING. *Introductory Applied Physics*

HALLIDAY and RESNICK. *Physics for Students of Science and Engineering, Part II*

[1] See Bibliography for publishers.

KLOEFFLER. *Principles of Electronics*

LISTER. *Electric Circuits and Machines*

LURCH. *Fundamentals of Electronics*

NATIONAL SCIENCE FOUNDATION. *American Institute of Physics Handbook*

PECK. *Electricity and Magnetism*

SEARS and ZEMANSKY. *College Physics, Part II.*, 3d ed.

SITZ and KOEFFLER. *Basic Theory in Electrical Engineering.*

TIMBIE. *Basic Electricity for Communications.*

WEBER, WHITE, and MANNING. *Physics for Science and Engineering*

Visual Aids

Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill.:
- *Series and Parallel Circuits*
- *What Is Electricity*
- *Electro-Dynamics*
- *Electrons*
- *Magnetism*

United World Films, Inc., 1445 Park Avenue, New York 29:
- *Capacitance*
- *Diodes*
- *Ohm's Law*
- *RCL—Resistance Capacitance Inductance*
- *Voltaic Cell, Dry Cell, and Storage Battery.*

S 223, Hydraulics and Pneumatics

Hours Required

Class 2; Laboratory 4

Description

A study of the basic components of hydraulic and pneumatic systems and how they are combined to build up various circuits.

The emphasis is on the use of hydraulics and pneumatics for power transmission and for control purposes. Both subject areas are treated as basic sciences with emphasis on mathematical analysis and the scientific method.

It is recommended that individual term problems requiring a significant amount of handbook design be required for this course.

Prerequisite—Mathematics I and II.

Major Divisions

	Class hours	Laboratory hours
I. Introduction to Hydraulics	1	2
II. Principles of Power Hydraulics	3	4
III. Hydraulic Fluids and Flow Measurement	2	4
IV. Hydraulic Pumps	3	4
V. Control Valves	3	6
VI. Hydraulic Motors	2	4
VII. Accessories	1	2
VIII. Hydraulic System Design	5	14
IX. Pneumatic Power Unit	2	4
X. Pneumatic Controls	3	4
XI. Air Cylinders	2	4
XII. Pneumatic Circuitry	4	12
XIII. Combination Systems—Air and Oil	3	4

I. Introduction to Hydraulics
- A. Class—1 hour
  1. The scope of hydraulics
     - a. Importance of hydraulics in engineering
     - b. Importance of hydraulics to the technician
  2. The importance of hydraulics in industry
     - a. The potential uses for hydraulics in industry
     - b. Reasons for use of hydraulic-operated equipment over other means
  3. Assignments, term project, notebook, problems, and tests
- B. Laboratory—2 hours
  1. Inspect industrial hydraulic equipment applications.
  2. Inspect various units in hydraulic equipment.

II. Principles of Power Hydraulics
- A. Class—3 hours
  1. Physical laws and principles
     - a. Power—its meaning, formula
       - (1) Force—pressure—p.s.i.
       - (2) Atmospheric
     - b. Work—its meaning, formula
       - (1) Torque
       - (2) Horsepower
  2. Physical properties of liquids
     - a. Differences between solids, liquids, and gases
     - b. Pascal's law
       - (1) Meaning
       - (2) Applications
     - c. Mechanics of liquids
       - (1) Forms of energy
         - (a) Potential
         - (b) Kinetic
         - (c) Heat
       - (2) Liquids in force multipliers
       - (3) Liquids and transfer of motion
     - d. Characteristics of flow
       - (1) Static factors
         - (a) Static pressure vs. heat energy
         - (b) Potential energy vs. kinetic energy
       - (2) Dynamic factors
         - (a) Bernoulli's principle, and applications
         - (b) Kinetic energy—applications
- B. Laboratory—4 hours
  1. Problems in levers, vector principles.
  2. Problems in torque, force, pressure, and horsepower.

3. Demonstration experiment—Pascal's law.
4. Demonstration experiment—properties of liquids.
5. Demonstration experiment—Achimedes' principle.
6. Specific gravity experiment and problems.

III. Hydraulic Fluids and Flow Measurement
A. Class—2 hours
1. Reservoirs, strainers, and filters
a. Principles and characteristics of reservoirs
b. Types and principles of strainers and filters
2. Hydraulic piping and fitting
a. Classifications—JIC standards
b. Selection (use of charts and layout)
c. Installation
d. Packing
3. Hydraulic fluids
a. Requirements of a hydraulic fluid
b. Characteristics of hydraulic oils
(1) Initial suitability
(a) Viscosity and viscosity index
(b) Pour Point
(c) Oxidation stability
(d) Rust prevention
(e) Foaming
c. Maintenance and storage of hydraulic oils
B. Laboratory—4 hours
1. Demonstration experiment in atmospheric pressure and measuring instruments in this area.
2. Inspect reservoirs, strainers, and filters.
3. Inspect pipes, tubing, hose and fittings, and study of applications.
4. Study and report on fluid flow, free flow, and within pipes.
5. Study hydraulic symbols and circuit layouts.
6. Study packing and sealing devices.
7. Demonstration experiment—Bernoulli's principle.
8. Demonstration experiment on measurement of fluid flow by:
a. Weir
b. Pitot tube
c. Venturi Tube flowmeter
d. Orifice
e. Open-flow approximation
9. Study characteristics of hydraulic fluids.

IV. Hydraulic Pumps
A. Class—3 hours
1. Purpose of hydraulic pumps
2. Performance ratings
3. Classification of hydraulic pumps
a. Principles of operation of nonpositive displacement pumps
(1) Centrifugal pumps (volute and diffuser)
(2) Propeller pumps
(3) Mixed flow pumps
b. Principles of operation ot positive displacement pumps
(1) Rotary pumps—gear, lobe, vane, or piston-type rotary
(2) Riciprocating pumps
B. Laboratory—4 hours
1. Problems in calculation of friction loss in pipes under varying conditions.
2. Problems in calculation of horsepower requirements.
3. Study of principles of operation, application, and performance characteristics of various pumps.
a. positive
b. nonpositive

V. Control Valves
A. Class—3 hours
1. Introduction to valves
a. types
b. classification—ratings
2. Pressure control valves
a. Relief valves
b. Pressure-reducing valves
c. Sequence valves
d. Pressure switches
3. Directional control valves
a. General classification
(1) Spool types and rotary types
(2) Two-, three-, and four-connection types
(3) Flow paths
b. Specific types
(1) Manual
(2) Pilot operated
(3) Solenoid controlled
(4) Solenoid-pilot controlled
c. Check valves
(1) Simple or standard type

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(2) Prefill type
(3) Foot valve
(4) Pilot operated
4. Flow control valves
a. Gate, plug, and needle valves
b. Pressure compensated flow control valves

B. Laboratory—6 hours
1. Study valve operation, application, and problems and diagnosis in use in various hydraulic circuits.
a. Directional control valve types
b. Flow control valve types
c. Pressure control valve types
2. Study methods used to operate various types of valves.
a. Manual
b. Pressure
c. Magnetic or solenoid
d. Combination

VI Hydraulic Motors
A. Class—2 hours
1. Rotary
a. Classifications
b. Ratings—torque—speed
2. Rams
a. Classifications
b. Ratings
B. Laboratory—4 hours
1. Study operation and applications of hydraulic motors.
2. Calculate requirements of pressure, volume, speed, and torque in various applications of hydraulic motors.
3. Horsepower and torque testing with plotting on graphs.

VII. Accessories
A. Class—1 hour
1. Principles of operation of accumulators
2. Principles of heat exchangers, oil coolers, oil filter, and seals and packing
B. Laboratory—2 hours
1. Study principles and applications of accumulators, heat exchangers, oil coolers.
2. Calculate various applications using accumulators, heat exchangers, and oil coolers.
a. Selection of size
b. Efficiency
c. Heat dissipation

VIII. Hydraulic System Design
A. Class—5 hours
1. Hydraulic circuits
a. Applications—automotive systems, aircraft systems, instrumentation and control, and industrial machines and tools
b. Troubleshooting
c. Maintenance of hydraulic systems
B. Laboratory—14 hours
1. Visit to industrial plants.
2. Make performance tests of operating systems.
3. Work on special design problems.

IX. Pneumatic Power Unit
A. Class—2 hours
1. Construction and principle of operation of the compressor
2. Cylinder arrangements
3. Air tank construction and dimensions
4. Pressure switch control
5. Coupling motor to compressor
6. Power requirements
7. R.F.L. units (regulator, filter, lubricator)
B. Laboratory—4 hours
1. Examine construction of various types of filters and lubricators.
2. Examine construction and flow path of pressure regulators.
3. Test to determine operational characteristics of pressure regulators.
4. Measure power consumption at various pressures per unit of air volume delivered.

X. Pneumatic Controls
A. Class—3 hours
1. Directional control valves, construction and operation
a. Four-way valves, manual
b. Three-way valves, manual
c. Pilot operated valves
d. Solenoid operated valves
2. Flow control valves, construction and operation
a. Manually operated
b. Cam-operated
3. Sequence valves
a. Construction and principle of operation
b. Location in circuit

B. Laboratory—4 hours
  1. Examine construction and study internal path of flow through
    a. Directional control valves
    b. Flow control valves
    c. Sequence valves
  2. Test operational characteristics of
    a. Directional control valves
    b. Flow control valves
    c. Sequence valves

XI. Air Cylinders

A. Class—2 hours
  1. Types of air cylinders
    a. Light, medium, heavy
    b. Tandem
    c. Duplex
    d. Double-end
  2. Cylinder parts
    a. Tube
    b. Cover
    c. Packing gland
    d. Cushion assembly
    e. Piston and piston seals
    f. Rods
  3. Installation, application, and maintenance

B. Laboratory—4 hours
  1. Examine internal construction and flow path through various types of cylinders.
  2. Measure cylinder air consumption at various thrusts.
  3. Measure piston speed as it is affected by such variables as friction, volume, and restrictions.

XII. Pneumatic Circuitry

A. Class—4 hours
  1. Power-operated holding devices
    a. Advantages and accuracy
    b. Power chucking applications
    c. Power-operated mandrels
    d. Power-operated collets
    e. Clamping devices
  2. Pneumatic safety circuits
    a. Protection when pressure drops
    b. Protection against overloads
    c. Interlock for machine protection
    d. Emergency reversal
    e. Holding at two pressure levels
    f. Safeguarding the operator's hands
  3. Remote control of pneumatic systems
    a. Bleed-type, pilot-operated valves
    b. Pressure-type, pilot-operated valves
    c. Pilot-operated systems
    d. Solenoid-operated systems
    e. Cam operated limit switches

B. Laboratory—12 hours

Set up and operate circuits involving the following methods of control:
  1. Manual
  2. Mechanical
  3. Pilot
  4. Solenoid.

XIII. Combination Systems—Air and Oil

A. Class—3 hours
  1. Applications and advantages of combination systems
  2. Air controlled, hydraulic valves
  3. Oil controlled, air valves
  4. Air control of multiple hydraulic circuits
  5. Air as a cushion for hydraulic systems

B. Laboratory—4 hours

Set up and operate circuits involving air and oil:
  1. Air-hydraulic rapid traverse circuit
  2. Air loading, hydraulic performance circuit
  3. Damping circuit.

Texts and References [1]

BLACK AND LITTLE. *An Introductory Course in College Physics*, 4th ed.
ERNST. *Oil Hydraulic Power and Its Industrial Application*
FURRY, PURCELL, and STREET. *Physics for Science and Engineering Students*
NATIONAL SCIENCE FOUNDATION. *American Institute of Physics Handbook*
NAVPERS 16193. *Basic Hydraulics*
STEWART. *Hydraulic and Pneumatic Power for Production*
THEODORE AUDEL & Co., *Pumps-Hydraulics and Air Compressors.*

Visual Aids

Hydraulics, The Texas Company, P.O. Box 6171, Dallas, Tex. A visual aid under S 223

[1] See Bibliography for publishers.

Auxiliary and Supporting Technical Courses

A 132, Technical Reporting

Hours Required

Class, 2; Laboratory, 0

Description

A natural and vital extension of G 123, Communication Skills intended to help the student achieve greater facility in his use of the language, both spoken and written. Using the basic skills previously acquired, the student is introduced to the practical aspects of preparing reports and communicating within groups.

Emphasis is upon techniques for collecting and presenting scientific data by means of informal and formal reports, and special types of technical papers. Forms and procedures for technical reports are studied and a pattern is established for all forms to be submitted in this and other courses.

Major Divisions

	Class hours
I. Reporting	5
II. Technical Report Writing	12
III. The Research Paper	9
IV. Group Communication	8

I. Reporting—5 hours
  1. Nature and types of reports
  2. Objective reporting
  3. Methods of slanting a report
  4. Critical evaluation of a report

II. Technical Report Writing—12 hours
  1. The scientific method
     a. Meaning of the method
     b. Characteristics of the scientific method
     c. Essentials of scientific style
     d. The problem concept
  2. The techniques of exposition
     a. Definitions
     b. Progression
     c. Elements of style
     d. Analysis of examples
  3. The report form
     a. Characteristics
     b. Functions
     c. Informal reports
     d. The formal report
     e. Preparation
     f. Special types of papers

III. The Research Paper--9 hours
  1. Subject and purpose
  2. Source materials: bibliographical tools, periodical indexes, the library
  3. Organizing the paper
     a. A working bibliography
     b. Notes and the outline
     c. The rough draft
     d. Quoting and footnoting
     e. The final paper
  4. Oral and written presentation of the paper

IV. Group Communication—8 hours
  1. The problem-solving approach
     a. Stating and analyzing the problem
     b. Proposing solutions
     c. Selecting and implementing a solution
  2. Participating in group communication
     a. The chairman—duties and qualifications
     b. Rules of order
     c. The panel discussion and symposium
     d. Group investigation

Texts and References [1]

BLICKE and HOUP. *Reports for Science and Industry*

BUCKLER and MCAVOEY. *American College Handbook of English Fundamentals*

CROUCH and ZETLER. *A Guide to Technical Writing*

DEAN and BRYSON. *Effective Communication*

[1] See Bibliography for publishers.

DeVitis and Warner. *Words in Context*
Gerber. *The Writer's Resource Book*
Guam, Graves, and Hoffman. *Report Writing*
Gunning. *The Technique of Clear Writing*
Harwell. *Technical Communications*
Hicks. *Successful Technical Writing*
Kegel and Stevens. *Communication: Principles and Practices*
Lee. *Language Habits in Human Affairs*
Marder. *The Craft of Technical Writing*
McCrorie. *The Perceptive Writer, Reader, and Speaker*
Perrin and Smith. *The Perrin-Smith Handbook of Current Usage*
Philco Technological Center. *Technical Writing Guide*
Pieper and Davis. *Guide to Technical Reports*
Rhodes and Johnson. *Technical Report Writing*
Roget. *College Thesaurus*
Santmyers. *Practical Report Writing*
Schutte and Steinberg. *Communication in Business and Industry*
Souther. *Technical Report Writing*
Stewart, Hutchinson, Lanman, and Zimmer. *Business English and Communications*
Strunk and White. *The Elements of Style*
Thompson. *Fundamentals of Communication*
Ulman and Gould. *Technical Reporting*
Zetler and Crouch. *Successful Communication in Science and Industry*

Visual Aids

Language in Action Series (16 mm films), National Educational Television Film Service, Audio-Visual Center, Indiana University, Bloomington, Ind.:
- Hayakawa, S. I. *Experience as Give and Take*
- ———. *Talking Ourselves Into Trouble*
- ———. *Words That Don't Inform*

McMurry-Gold Productions, 139 South Beverly Drive, Beverly Hills, Calif.:
- *Person to Person Communication*

National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.:
- *It's an Order*

A 204, Strength of Materials

Hours Required

Class 3; Laboratory, 2

Description

Study is made of the internal stresses and deformation of elastic bodies resulting from the action of external forces. The application of this principle of strength of materials is considered fundamental in the design of structures and machines. Emphasis is given to the analysis of the simple and combined stresses and properties of materials to meet the functional requirements in design. In this course, strength of such elements as riveted joints, beams, columns, shafts, and keys are determined.

Major Divisions

	Class hours	Laboratory hours
I. Strength of Materials as Related to Product Design	2	0
II. Properties of Materials	3	4
III. Review of Statics	3	0
IV. Stress and Strain	6	4
V. Riveted and Welded Joints and Pressure Vessels	6	2
VI. Center of Gravity and Centroids	3	0
VII. Moment of Inertia	3	0
VIII. Beams—Shear Forces	3	4
IX. Beams—Bending Moments	3	4
X. Design of Beams	5	4
XI. Torsion, Shafts, Shaft Couplings and Keys	5	4
XII. Combined Stresses	3	4
XIII. Columns	3	2
XIV. Indeterminate Beams	3	0

I. Strength of Materials as Related to Product Design
- A. Class—2 hours
  1. Strength
  2. Weight
  3. Sales appeal
  4. Ease of manufacture
  5. Availability and cost
  6. Life of the product
- B. Laboratory—0 hours

II. Properties of Materials
- A. Class—3 hours
  1. Strength
     - a. Tension
     - b. Compression
     - c. Shear
     - d. Bending
  2. Elasticity
  3. Stiffness
  4. Resilience
  5. Ductility
  6. Hardness
  7. Malleability
  8. Toughness
  9. Machinability
  10. Fatigue
  11. Creep
  12. Durability
- B. Laboratory—4 hours

  Load machine and test various samples for: tension, compression, and shear. Test samples for hardness, malleability, and ductility.

III. Review of Statics
- A. Class—3 hours
  1. Composition and resolution of forces
  2. Conditions of equilibrium
  3. Inertia
  4. Moments
- B. Laboratory—0 hours

IV. Stress and Strain
- A. Class—6 hours
  1. Load and unit stress
  2. Strain
  3. Hooke's law
  4. Young's Modules
  5. Thermal stress

B. Laboratory—4 hours
   1. Run complete tension test.
   2. Plot stress-strain diagrams.

V. Riveted and Welded Joints and Pressure Vessels
   A. Class—6 hours
      1. Types of riveted joints
      2. Types of failures
      3. Stresses in riveted joints
      4. Terminology and codes
      5. Efficiency of riveted joints
      6. Welded joints
      7. Analysis of forces on thin-walled cylinders
      8. Application of riveted and welded joints to thin-walled cylinders
      9. Typical problems
   B. Laboratory—2 hours
      1. Perform tests on riveted joints for various types of failures.
      2. Determine efficiency of joints.
      3. Perform tests on various types of welded joints.

VI. Center of Gravity and Centroids
   A. Class—3 hours
      1. Definition of center of gravity
      2. Distinction between center of gravity and centroid
      3. Moments of areas
      4. Centroids of composite areas
      5. Practical application
   B. Laboratory—0 hours

VII. Moment of Inertia
   A. Class—3 hours
      1. Definition
      2. Determination of moment of inertia of regular and composite areas
      3. Effect of moment of inertia on strength of materials
   B. Laboratory—0 hours

VIII. Beams—Shear Forces
   A. Class—3 hours
      1. Types of beams
      2. Beam theory
      3. Shear force diagram
   B. Laboratory—4 hours
      1. Test various types of beams for shear.
      2. Record and compare readings.
      3. Draw shear diagrams.

IX. Beams—Bending Moments
   A. Class—3 hours
      1. Types of loading
      2. Determination of bending moments
      3. Moment diagrams
      4. Bending moment from shear diagram area
   B. Laboratory—4 hours
      1. Test beam for bending with single concentrated load.
      2. Test beam with several concentrated loads.
      3. Test beam with moving loads.
      4. Draw moment diagrams.

X. Design of Beams
   A. Class—5 hours
      1. Classification of beams
      2. Stress due to bending
      3. Horizontal and vertical shear stresses
      4. Load effects on various shapes of beams
      5. Beam deflection
      6. Radius of curvature
      7. Lateral buckling
   B. Laboratory—4 hours
      1. Determine bending and shear stresses and deflections of various cross-sectional shaped beams under different loads.
      2. Calculate and plot the test values.

XI. Torsion, Shafts, Shaft Couplings and Keys
   A. Class—5 hours
      1. Definitions
      2. Torsional shearing stress
      3. Angle of twist
      4. Power transmission
      5. Types of couplings
      6. Stresses in couplings
      7. Design of keys
   B. Laboratory—4 hours
      1. Measure torsional stresses in shafts.
      2. Test various types of shaft couplings for torsional deformation and ultimate stress under different tangential load conditions.
      3. Test keys for shear.
      4. Tabulate and plot findings.

XII. Combined Stresses
   A. Class—3 hours
      1. Principle of superposition
      2. Combined axial and bending stresses

3. Eccentrically loaded short compression members
4. Eccentric loading of machine members
5. Eccentrically loaded riveted joints
6. Combined shear stresses
7. Combined bending and torsion

B. Laboratory—4 hours
1. Perform compression tests on eccentrically loaded short members.
2. Perform tension and shear tests on eccentrically loaded riveted joints.
3. Calculate stresses.

XIII. Columns

A. Class—3 hours
1. Definition
2. Limitations
3. Slenderness ratio
4. Radius of gyration
5. Categories of columns
6. End conditions
7. Column formulas

B. Laboratory—2 hours
1. Test some of the more common shaped columns of various lengths for buckling.
2. Plot test results and draw comparative diagrams.

XIV. Indeterminate Beams

A. Class—3 hours
1. Definition
2. Types
3. Methods of supporting
4. Methods of loading
5. Continuous beam

B. Laboratory—0 hours

Texts and References [1]

BASSIN and BRODSKY. *Statistics and Strength of Materials*
BOYD and FOLK. *Strength of Materials*
MARIN and SAUER. *Strength of Materials*, 2d ed.
MERRIMAN. *Strength of Materials*
POORMAN. *Strength of Materials*

[1] See Bibliography for publishers.

A 213, Statistics and Quality Control

Hours Required

Class, 2; laboratory, 2

Description

An elementary approach to the statistical techniques used in the control of the quality requirements of manufactured articles. The course is primarily intended for those who have had no previous experience, although its content is broad enough so that students with some experience will find it both valuable and engaging. The entire course is woven around a core which consists of the application of formulas and control charts.

The main activities covered include sampling inspection techniques, use of inspection tools and instruments, construction and interpretation of Showhart control charts for variables, defects, and fraction defective.

Concerted effort is put on the relationship of theoretical concepts to practical manufacturing operations and processes so that assignable causes and weaknesses in a process can be readily isolated and recognized.

Major Divisions

	Class hours	Laboratory hours
I. Introduction	2	0
II. Numbers and measurements	2	2
III. Frequency Distribution	6	6
IV. The Control Chart	6	6
V. Fraction Defective	6	4
VI. Number of Defects	4	4
VII. Sampling	8	12

I. Introduction
- A. Class—2 hours
  1. Objectives
  2. Organization
  3. Measuring Tools and Instruments
- B. Laboratory—0 hours

II. Numbers and Measurements
- A. Class—2 hours
  1. Accuracy of measurements
  2. Applying approximate numbers
  3. Significant numbers
- B. Laboratory—2 hours

  Perform exercises in recognizing significant numbers.

III. Frequency Distribution
- A. Class—6 hours
  1. Pictures of variations
  2. Graphic representation
  3. Sources of variation
  4. Examples of distributions
  5. Interpretation of distributions
- B. Laboratory—6 hours
  1. Make a series of measurements of similar items and tabulate their frequencies. Determine the range, average median, and the mode. Find the probability of the occurrence of the value of the mode.
  2. Construct a bar chart, histogram, and a frequency polygon.

IV. The Control Chart
- A. Class—6 hours
  1. Description of distributions
  2. Development of a control chart
  3. Rational subgrouping
  4. Interpretation of a control chart
  5. Comparison of a process and specification
  6. Modified and preliminary control limits
- B. Laboratory—6 hours
  1. Analyze a typical industrial frequency distribution of measurements taken from similar machined parts.
  2. Construct an X and R control chart.
  3. Interpret the control chart in terms of the process.
  4. Calculate the upper and lower control limits.

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V. Fraction Defective
   A. Class—6 hours
      1. P charts
      2. Calculations of fraction defective
      3. Control limits for P charts
      4. Uses of the P chart
   B. Laboratory—4 hours
      1. Calculate for fraction defective through the use of visual inspection and limit gages.
      2. Calculate the control limits on a p chart for the above values.
      3. Determine the assignable causes for the number of fraction defective.

VI. Number of Defects
   A. Class—4 hours
      1. C charts
      2. Control charts for defects per unit
      3. Conditions for a C chart
      4. Uses of the C chart
   B. Laboratory—4 hours
      1. Inspect similar parts for attributes and construct a PN chart.
      2. Calculate the upper and lower control limits for number of defectives and determine reasons for a process being out of control.

VII. Sampling
   A. Class—8 hours
      1. Purpose
      2. Problems of sampling
      3. Theory of sampling
      4. Use of probability theory of sampling
      5. Operating characteristic curve
      6. Average out-going quality curve
      7. Average sample number curve
      8. Total amount of inspection curve
      9. Types of sampling plans
      10. Kinds of protection
      11. Use of sampling tables
   B. Laboratory—12 hours
   Determine the probability of a number of defectives which might be found in various samples of a given size from a source that is a certain fraction defective, using the binomial probability distribution, and compare the results with Poisson's approximation.

Texts and References [1]

BOWKER and LIEBERMAN. *Handbook of Industrial Statistics.*

BURR. *Engineering Statistics and Quality Control.*

CARSON. *Production Handbook.*

DUNCAN. *Quality Control and Industrial Statistics.*

FREEDMAN and MOUSHIN. *A Basic Training Manual on Statistical Quality Control.*

GRANT. *Statistical Quality Control.*

PEACH. *An Introduction to Industrial Statistics and Quality Control.*

[1] See Bibliography for publishers.

A 293, Industrial Organizations and Institutions

Hours Required

Class, 3; Laboratory, 0

Description

A description and analysis of the roles played by labor and management in the economy of the United States is presented. Approximately one-half of the classroom time is devoted to labor-management relations, including the evolution and growth of the American labor movement and the development and structure of American business management. A study is made of the legal framework within which labor-management relations are conducted and the responsibilities of each in a democratic system of government. The second half of the course pertains to labor-economics as applied to the forces affecting labor supply and demand, problems of unemployment reduction and control, and wage determination on the national, plant, and individual levels. Emphasis centers upon current practical aspects of our industrial society with historical references intended only as background material to interpret trends and serve as points of departure.

Major Divisions

	Class hours
I. Labor in an Industrial World	10
II. Management in an Industrial Society	10
III. The Collective Bargaining Process	12
IV. Dynamics of the Labor Market	8
V. Wage Determination	8
VI. The Balance Sheet of Labor-Management Relations	3

I. Labor in an Industrial World—10 hours
1. The nature and scope of the Industrial Revolution
   a. The factory system
   b. Occupational trends
   c. Mechanisms of adjustment
2. The evolution of American labor unions
   a. Nature of early unions
   b. Emergence of "business" unionism
   c. The changing role of government
3. Structure and objectives of American unions
   a. Objectives in collective bargaining
   b. Political objectives and tactics
   c. Structure of craft and industrial unions
   d. Movement toward unity—the A.F. of L.-C.I.O. merger

II. Management in an Industrial Society—10 hours
1. The rise of big business
   a. Economic factors
   b. Dominance of the corporate firm
   c. Government, public policy, and big business
2. The "Managerial Revolution"
   a. Changing patterns of ownership and management
   b. "Scientific" management
   c. Twentieth Century trends
3. Structure and objectives of American industry
   a. Production for profit: an "Affluent Society"
   b. Structure of industry-organizational forms
   c. Ethics in a competitive economy

III. The Collective Bargaining Process—12 hours
1. Legal framework
   a. Common law provisions
   b. The growth of statute laws
      (1) The antitrust laws
      (2) The Addamson and LaFollette Laws
      (3) Norris-LaGuardia
      (4) Wagner Act
      (5) Taft-Hartley
      (6) Landrum-Griffin and beyond
2. Management and collective bargaining

3. Bargaining procedures and tactics, including conciliation and mediation processes
4. Issues in collective bargaining
   a. Security issues
   b. Working conditions
   c. Money matters
5. Strikes and lockouts: tactics and prevention
6. Evaluation of collective bargaining

IV. Dynamics of the Labor Market—8 hours
1. Labor supply and the market
   a. Level and composition of the labor force
   b. Changing patterns of employment
   c. Some questions about labor supply and the market
2. Reduction and control of unemployment
   a. Types of unemployment
   b. Proposed schemes of employment stabilization
   c. Continuing problems
3. Labor mobility
   a. Types of labor mobility
   b. Deterrents to labor mobility
   c. Suggested programs to improve labor mobility

V. Wage Determination—8 hours
1. Wages, prices, and employment
   a. Meaning of wages
   b. Wages and the productive process
   c. The problem of inflation
2. Wages and the national income
   a. Concepts of measurement and productivity
   b. Determinants of productivity
   c. The distribution of national income
3. Wage structures
   a. Occupational differences
   b. Geographic patterns
   c. Industry patterns
   d. Wage determination: plant level, individual wages

VI. The Balance Sheet of Labor-Management Relations—3 hours
1. The control and elimination of poverty in a modern industrial state
   a. The extent of poverty
   b. The attack on poverty
   c. Trends and portents
2. Justice and dignity for all in an industrial democracy
   a. The worker—status and goals
   b. Management—rights and responsibilities
   c. The future of capitalistic society

Texts and References [1]

BLOOM and NORTHRUP. *Economics of Labor Relations*, 4th ed.
BURBASH. *Unions and Union Leadership: Their Human Meaning.*
———, *The Practice of Unionism.*
CHAMBERLIN. *The Economic Analysis of Labor Union Power.*
BULLES. *Labor in America.*
ELLIS. *The Meaning of Modern Business: An Introduction to the Philosophy of Large Corporate Enterprise.*
FAULKNER. *American Economic History*, 8th ed.
GEARY. *The Background of Business*, 2d ed.
GITLOW. *Labor Economics and Industrial Relations*
GREGORY. *Labor and the Law*, 2d ed.
GRIMSHAW. *Organizational Behavior—Cases and Readings*
KERR and others, *Industrialism and Man*
KUHN. *Labor Institutions and Economics*
LEISERSON. *American Trade Union Democracy*
LESTER. "Shortcomings of Marginal Analysis for Wage and Employment Problems" in *American Economic Review*, XXXVI, p. 63–82.
LINDBLOM. *Unions and Capitalism*
MACHLUP. "Marginal Analysis and Empirical Research" in *American Economic Review*, XXXVI, p. 519–54.
MCGREGOR. *The Human Side of Enterprise.*
MORTON. "Trade Unionism, Full Employment and Inflation" in *American Economic Review*, XL, p. 13–39.
PFIFFNER. *Administrative Organization*
PHELPS. *Introduction to Labor Economics*
REES. "Patterns of Wages, Prices and Productivity" in *Wages, Prices, Profits and Productivity*, p. 11–35.
REYNOLDS. *Labor Economics and Labor Relations*, 3d ed.
RICHBERG. *Labor Union Monopoly*
SAMUELSON. *Economic Theory and Wages*
SELDEN. "Cost-Push versus Demand-Pull Inflation."
SLICHTER, HELAY and LIVERNASH. *The Impact of Collective Bargaining Upon Management*
SULTAN. *Labor Economics*
TAFT. *Economics and Problems of Labor*, 3d ed.
U.S. DEPARTMENT OF LABOR. *The American Worker Fact Book*
——— *Studies of the Economic Effects of the Dollar Minimum Wage*
——— "Twenty Years of Unemployment Insurance in the United States"
——— BUREAU OF LABOR STATISTICS, *Population and Labor Force Projections for the United States*

[1] See Bibliography for publishers.

Visual Aids

Bargaining Collectively, Teaching Film Custodians, 25 West 43d Street, New York.

Big Enterprise in the Competitive Systems, The Brookings Institution, Washington, D.C.

Decision: Constitution and the Labor Union, University of Indiana, Bloomington, Indiana.

Internal Organization, New York: McGraw-Hill Book Co., Inc.

Job Evaluation and Merit Rating, New York: McGraw-Hill Book Co., Inc.

Labor Movement: Beginnings and Growth in America, Coronet Films, Inc., Coronet Building, Chicago 1.

Productivity—Key to Plenty, Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Illinois.

Working Together, Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Illinois.

General Courses

G 100, Orientation

Hours Required

Class, 1; Laboratory, 0

Description

A brief overview of the field of occupations is followed by a discussion of the work life of technical personnel, the part that interests and aptitudes play in the successful attainment of vocational goals, and how one goes about evaluating these qualities. Field trips give the student the opportunity to see the mechanical technician in action, while individual interviews give the instructor first-hand information about the student.

Major Divisions

	Class hours
I. The School	2
II. Technical Personnel	7
III. The Program of Study	2
IV. Field Trips	5
V. Individual Counseling	1

I. The School—2 hours
   1. Purpose of orientation
   2. The technical institute, its place in education, the associate degree, accreditation
   3. How and when to study
   4. What is counseling, where is it obtained
   5. Scholarship and assistance programs

II. Technical Personnel—7 hours
   1. The world of work
      a. Occupat' nal levels and preparation
      b. Qualifications for typical occupations
   2. Aptitudes required in mechanical technology
   3. Assessing personal aptitudes—guidance and testing
   4. Nature of technician work
      a. The engineering team
      b. Typical work of the technician
      c. Departments in industrial concerns employing technicians
   5. Job opportunities
      a. Wages
      b. Promotional possibilities
      c. Local industrial scene in mechanical technology
      d. Further schooling
   6. Employment practices
      a. Recruitment
      b. Tests
      c. Interviews
      d. School placement department

III. The Program of Study—2 hours
   1. Purpose of courses
      a. General education
      b. Related subjects
      c. Technical subjects
   2. Arrangement of the curriculum
      a. Designing major
      b. Manufacturing major
   3. The grading system and tests
   4. Opportunities in noninstitute courses
   5. Extracurricular activities
   6. The curriculum planning sheet—a guide to each semester's program

IV. Field Trips—5 hours
   1. Preparation for trips to several industrial plants; what to look for, type of question to be asked of industry
   2. Tours planned specifically to show the technician at work
   3. Discussion of trips, conclusions that may be drawn

V. Individual Counseling—1 or more hours as required
   1. Establish rapport with each student, discussion of individual's objectives, aptitudes, progress in school to date, study habits, etc.
   2. Schedule further counseling sessions as needed.
   3. Arrange for the services of others (school psychologist, testing department, other technical area instructor if student is uncertain of interest in mechanical technology).

Texts and References[1]

BERGEN. *Putting Technicians to Work*
NATIONAL ASSOCIATION OF MANUFACTURERS, *Your Opportunities in Industry as a Technician* The Association, 2 East 48th Street, New York 17
STATON. *How to Study*

Current magazine and newspaper articles

[1] See Bibliography for publishers.

Visual Aids

Coronet Films, Coronet Building, Chicago, Ill.:
- *Aptitudes and Occupations*
- *Mechanical Aptitudes*
- *Your Earning Power*

Encyclopaedia Britanica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill.:
- *Planning your Career*

Iowa State University, Ames, Iowa:
- *Getting Acquainted with Engineering*

Vocational Guidance Films, Des Moines, Iowa:
- *Engineering*

Charts and graphs illustrating employment trends in industry.
Job classification and qualification charts.
Sample intelligence, aptitude, and personality tests.

C 123, Communication Skills

Hours Required

Class, 3; Laboratory, 0

Description

This course is designed to enhance the student's skill in reading, writing, listening, and speaking. Topics for student oral and written reports are chosen from material discussed in their technical courses. The course material correlates and integrates the basic communication skills with practical industrial situations instead of treating them as discrete topics. The practical aspect of communication problems dominates the course.

Major Divisions

	Class hours
I. The Idea of Communication: A Point of View	9
II. Investigating and Designing the Composition	15
III. Developing the Composition—Oral and Written	15
IV. Process Explanation	6
V. Grammatical Convention	6

I. The Idea of Communication: A Point of View—9 hours
  1. Analysis of the communication process
  2. Examination of the problems involved in the effective use of the basic communication skills
  3. Relationship of language and maladjustment
  4. Dynamics of language
     a. Changes by time, place, and environment
     b. Levels of usage
     c. View toward grammatical conventions
  5. Meaning and value in words and phrases

II. Investigating and designing the Composition—15 hours
  1. Choosing the subject
  2. Limiting the subject
  3. Determining the purpose
  4. Gathering, selecting, and organizing the material
  5. Examining the forms of discourse: argumentation, description, exposition, narration, persuasion
  6. Using aids: dictionary, thesaurus, library, note-taking, outlining.

III. Developing the Composition: Oral and Written—15 hours
  1. Being specific (words, ideas)
     a. Defining terms
     b. The process of definition
     c. Types of meaning—connotative, denotative
  2. Methods of presentation
  3. Organization
  4. Developing the central idea: forming, stating, supporting
  5. Composing the sentence, the paragraph, the whole composition—oral and written

IV. Process Explanation—6 hours
  1. The nature of expository composition
  2. Planning the explanation
  3. Presenting the explanation

V. Grammatical Convention—6 hours
  1. Forms, mechanics and usage
  2. Troublesome problems
     a. The sentence fragment and run-together sentence
     b. Commonly misspelled words and penmanship
     c. Verb-subject agreement, tense
     d. Paragraphing—stating and developing a main idea
     e. Punctuation and capitalization

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DEAN and BRYSON. *Effective Communication*

[1] See Bibliography for publishers.

DeVitis and Warner. *Words in Context*
Gerber. *The Writer's Resource Book*
Harwell. *Technical Communication*
Kegel and Stevens. *Communication: Principles and Practices*
Lee. *Language Habits in Human Affairs*
Marder. *The Craft of Technical Writing*
McCrorie. *The Perceptive Writer, Reader, and Speaker*
Perrin and Smith. *The Perrin-Smith Handbook of Current Usage*
Pieper and Davie. *Guide to Technical Reports*
Roget. *College Thesaurus*
Schutte and Steinberg. *Communication in Business Industry*
Stewart, Hutchinson, Lanham, and Zimmer. *Business English and Communication*
Strunk and White. *The Elements of Style*
Thompson. *Fundamentals of Communication*
Tracy and Jennings. *Handbook for Technical Writers*
Zetler and Crouch. *Successful Communication in Science and Industry*

Visual Aids

National Education Television Film Service, Audio-Visual Center, Indiana University, Bloomington, Ind. (16 mm films):

Language in Action Series—Hayakawa, S. I. *How to Say What You Mean; The Task of the Listener; What is the Meaning?*

Language and Linguistics Series—Smith, Henry Lee. *The Definition of Language; Dialects; Language and Writing.*

G 222, American Institutions

Hours Required

Class, 2; Laboratory, 0

Description

A study of the effect of American social, economic, and political institutions upon the individual as a citizen and as a worker. The course dwells upon current local, national, and global problems viewed in the light of our political and economic heritage. Standards of conduct are considered as guides to the obligations and privileges of an individual in a democratic society.

Major Divisions

	Class hours
I. Sociology	9
II. Economics	14
III. Government	11

I. Sociology—9 hours
1. The meaning and purpose of social science
2. The nature and characteristics of culture, society, and personality
   a. Integration of culture
   b. Consequences of cultural change
   c. Functions of culture and how it serves the individual
3. A system of group relationships
   a. Urban and rural communities
   b. Social stratification
   c. Intergroup tension
   d. Personality formation
   e. The family
   f. Education
   g. Religion

II. Economics—14 hours
1. Economic systems and their relationship to culture
   a. Want and resources
   b. Decisions of production
   c. Exchange of goods
2. Comparative economic systems
   a. Economic decisions under laissez faire
   b. Economic decisions in a mixed economy
   c. Economic decisions under socialism
3. Business organization and the American economy
   a. The relationship between the free enterprise concept and American culture
   b. The Industrial Revolution
   c. The rise of corporations
   d. Monopoly price
   e. The corporation and government regulation
4. Labor problems in an industrial society
   a. Labor before and after the Industrial Revolution
   b. The emergence of modern industrialism
   c. Labor organization as a compensating power
   d. The rise of the A.F. of L.
   e. The decline of unionism and the 1920's
   f. The New Deal and social legislation
   g. Birth of the C.I.O.
   h. Merger of AFL/CIO
   i. Post-war labor legislation and government regulation
5. The problem of the American consumer
   a. Advertising and the consumer
   b. Measures to aid the consumer
   c. Justification for a consumer's movement
6. The farmer and the American culture
   a. Technological revolution and its effect on society
   b. The farm price problem and the reasons for national concern
   c. National legislation designed to correct the farm surplus problem
      (1) Parity
      (2) Government purchasing programs
      (3) Acreage restrictions
      (4) Soil bank

d. World agricultural problems in comparison to the American problem
  (1) United Nations Technical Assistance Program
  (2) American Technical Assistance Programs
  (3) United Nations Food and Agriculture Organization

7. Prosperity without inflation
  a. The business cycle
  b. The cause of the business cycle
  c. Stabilizing the economy through the monetary policy
    (1) Reserve requirements
    (2) Open-market operations
    (3) Discount rate
    (4) Selective controls
  d. Fiscal policy as a stabilizer
    (1) Taxation increase or decrease
    (2) Government investment
  e. The built-in stabilizers of the business cycle
    (1) Unemployment insurance
    (2) Social Security payments
    (3) Old-Age Assistance Program
    (4) Payments to farmers under various agriculture programs

III. Government—11 hours

1. Society and the governing institutions
2. The Constitution, a foundation for American national, State and local government
  a. Constitutional development in America
  b. Confederation and federation
3. The political systems and political issues
  a. Elections
  b. Political parties and political issues
  c. Purpose of the electoral college
  d. Third parties
  e. Pressure groups
  f. The American voter
4. The President of the United States of America
  a. Chief administrator
  b. Chief foreign policymaker
  c. Commander-in-chief of the armed forces
  d. Veto power
5. Congress
  a. Powers of Congress
  b. Organization of Congress
  c. Congress and politics
6. The Federal Court System
  a. Supreme Court
  b. Circuit Court
  c. District Court
  d. Quasi courts
7. State and local government
  a. Federalism and State powers
  b. State constitutions
  c. The problem of State and local finance
  d. Forms of local government
8. Comparative political systems
  a. Capitalism
  b. Socialism
  c. Trends in world politics and how they affect American foreign policy
9. World politics and the United Nations
  a. Prestige and democracy abroad
  b. Review of American foreign policy
  c. Trends in world politics and how they affect American foreign policy

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ADRIAN. *State and Local Government*
BACH. *Economics*
BANNER, HILL, and WILBER. *The Contemporary World*
BELL and BERNARD. *Crowd Culture*
BIESANZ and MAVIS. *An Introduction to Social Science*
BISHOP and HENDLE. *American Democracy*
CARR, BERSTEIN, and MORRISON. *American Democracy in Theory and Practice*
CHAMBERLAIN. *Sourcebook on Labor*
CHINOY. *Society: An Introduction to Sociology*
FAULKNER and STARR. *Labor in America*
IRISH and PROTHRO. *The Politics of American Democracy*
MARK and SLATER. *Economics in Action*
OGG and RAY. *Essentials of American Government*
PELLING. *American Labor*
PHELPS. *Introduction to Labor Economics*
ROSS. *The Fabric of Society*
SERKIN. *Crisis of Our Age*
SWEEDLUN and CRAWFORD. *Man in Society*
WALETT. *Economic History of the U.S.*

Visual Aids

Man and His Culture, Encyclopedia Britannica, 1150 Wilmette Avenue, Wilmette, Illinois.
Productivity—Key to Plenty, Film, Inc., 1150 Wilmette Avenue, Wilmette, Illinois.
Social Classes in America, New York: McGraw-Hill Book Co., Inc.
The Pursuit of Happiness, Amalgamated Meat Cutters and Butcher Workmen of North America.
The Rise of Organized Labor, New York: McGraw-Hill Book Co., Inc.
Labor's Witness, United Automobile Workers Union.

[1] See Bibliography for publishers.

G 283, Psychology and Human Relations

Hours Required

Class, 3; Laboratory, 0

Description

Planned for the development of a better understanding of the human mechanism—its motivation and learning ability as related to interpersonal relations on the job. Employee selection, intelligence and aptitude tests, supervision, industrial conflict, and job satisfaction are considered. Attention is given to personal and group dynamics so that the student may learn to apply the principles of mental hygiene to his adjustment problems as a worker and as a member of society. Instruction is focused upon the practical applications of the principles guiding human behavior rather than their physiological origin or historical significance.

Major Divisions

	Class hours
I. A Practical Science	3
II. Basic Psychological Principles	13
III. Problems of Adjustment	7
IV. Vocational Industrial Problems	9
V. Factors of Supervision	11
VI. Communications in Industry	4
VII. Industrial Conflict	4

I. A Practical Science—3 hours
1. Orientation to subject: posing and solving problems from life situations
2. The scientific method:
   a. Awareness of problems
   b. Collection of data
   c. Hypothesis
   d. Testing hypothesis
   e. Confirmation or refutation

II. Basic Psychological Principles—13 hours
1. Motivation
   a. Nature and classification of motives
   b. Importance in understanding, predicting and controlling human behavior
   c. Application to advertising, business and industry
2. Emotions and feelings
   a. Origin, function and physical aspects
   b. Understanding and controlling
3. Frustration
   a. Causes
   b. Various reactions to frustration
   c. Application to industrial problems

III. Problems of Adjustment—7 hours
1. Abnormal reaction patterns
   a. Dynamics of mental and emotional disorders
   b. Chief classifications of disorders
   c. Principles of general semantics and relevance to understanding of abnormal reactions
2. Mental hygiene
   a. Kinds of therapy and their rationale
   b. Exploration of the concept of mental health
   c. Achieving and maintaining mental health

IV. Vocational Industrial Problems—9 hours
1. Vocational problems: vocational choice
   a. Factors in vocational choice: interests, attitudes, aptitudes, social abilities
   b. Getting the job
2. Vocational problems: on the job
   a. Success on the job: job satisfaction
   b. Promotion on the job: efficient study habits, effective thinking, intersocial problems

V. Factors of Supervision—11 hours
1. Employee selection
   a. Theory and art of interviewing
   b. Use of testing in industry
2. Employee evaluation
   a. Meaning and use of ratings, job evaluations, job analysis and description

b. Motion study and incentives in industry

3. Employee leadership

a. Group dynamics in industry

b. Factors in leadership, discipline and morale

c. Training methods

VI. Communications in Industry—4 hours

1. Requirements in industrial communications

2. Factors in evaluation

3. Influence on morale

VII. Industrial Conflict—4 hours

1. Formation and perpetuation of attitudes and beliefs

2. Factors of social conflict

3. Psychology of unionism

4. Psychology of organized conflict as exemplified in strikes and lockouts

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AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCES, "Automation," in *Annals*, March 1962.

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BELLOWS. *Psychology of Personnel in Business and Industry*

BLUM. *Industrial Psychology and Its Social Foundations*, rev. edition

———, *Readings in Experimental Industrial Psychology*. New York: Prentice-Hall, Inc.

CALHOON, NOLAND, and WHITEHALL. *Cases on Human Relations in Management*, New York: McGraw-Hill Book Co., Inc.

DUBIN. *The World of Work—Industrial Society and Human Relations*

GHISELLI, and BROWN. *Personnel and Industrial Psychology*

HEPNER. *Psychology Applied to Life and Work*

MAIER. *Principles of Human Relations: Applications to Management*

———, *Psychology in Industry*, 2d ed.

RYAN and SMITH. *Principles of Industrial Psychology*

SMITH. *Psychology of Industrial Behavior*

STAGNER. *The Psychology of Industrial Conflict*

[1] See Bibliography for publishers.

Visual Aids

Association Films, Inc., 347 Madison Avenue, New York, N.Y.:

Unconscious Motivation

Anti-Defamation League of B'nai B'rith, 515 Madison Ave., New York, N.Y.

Rumor Clinic

McGraw-Hill Book Co., Inc., 330 West 42d Street, New York, N.Y.:

Breakdown

Feeling of Depression

Feeling of Hostility

Man on the Assembly Line

Overdependency

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AMERICAN FEDERATION OF LABOR—CONGRESS OF INDUSTRIAL ORGANIZATIONS, Washington 25, D.C.

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Declines of Wage Incentives, AFL–CIO Bargaining Report, November, 1960

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Predetermined Time Systems in the U.S.A., Bertram Gottlieb, 1959

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———, *Structural Shop Drafting*, Vols. I and II. New York: the Institute.

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AMERICAN SOCIETY OF TOOL ENGINEERS, *Tool Engineers Handbook*, New York: McGraw-Hill Book Co., Inc.

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AUDEL, THEODORE & Co., *Pumps-Hydraulics and Air Compressor.* New York 10: The Company 49 E. 23d St.

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———, *Readings in Experimental Industrial Psychology.* New York: Prentice-Hall, Inc.

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Appendixes

A. Sample Instructional Materials

THE COURSE OUTLINE and course descriptions in this book are general in nature, suggesting areas of instruction and major study topics. Instructional materials should be prepared to supplement the use of textbooks and references. This is especially necessary in laboratory instruction where it is always advisable to organize the instruction around industrial applications of the principles being taught.

The sample instructional materials included in this appendix illustrate ways of expanding and supplementing the units of instruction shown in the outlines. Three guides are shown: one for a lecture unit and two that include both lecture and laboratory guides. A sample of student work is shown in the form of a student's laboratory report on which corrections and suggestions for improvement are written in by an instructor. The marking of reports is of extreme importance in making this aspect of technical instruction effective. Unless this marking is done as carefully and objectively as possible, the student may be misled and actually misinformed. Marking should also include attention to form, style, clarity of expression, and spelling.

Laboratory Report

Much of the effectiveness of formal training rests upon the standards required in reporting. Employers stress the importance of communications, especially for the liaison type jobs so often assigned to the technician. Perhaps the most thorough approach to this in the instructional program is found in the formal and informal reporting of laboratory work. This includes not only the basic "experiment" laboratory project, but also design problems, research studies, and field study of industrial installations.

The form and style of the formal report should be established early in the program in order to attain a degree of uniformity. "The Suggested Standards for Laboratory Reporting" included here are intended for the student's orientation; they follow accepted patterns of reporting. A common deficiency in student work is insufficient attention to detail. The guide used should direct attention to the importance of detail as well as logical conclusion in the reporting process.

Suggested Standards for Laboratory Report Writing

General Characteristics

Tests of equipment are usually summarized in the form of reports. In most cases the reports are submitted to those who have not been actively engaged in the tests; hence the reports must be clear and concise enough to leave no doubt concerning the method of test and the interpretation of the results.

The report should be written in the past tense and in the third person. It should be impersonal throughout, personal pronouns being avoided. The report must be complete in itself so that it can be followed by a reader without extensive knowledge of the test under consideration. A good report is thorough, orderly, neat, and grammatically correct.

Specifications

1. Write with ink or use a typewriter.
2. Use 8½ x 11 inch paper. (Ruled paper for handwriting)
3. Write on one side of the paper only.
4. Draw all illustrations, circuit diagrams, and curves neatly and carefully.
5. Letter or type all information on drawings, circuit diagrams, and curves. Do not mix lettering styles.
6. Assemble the sheets in the order given in the following report outline. Submit the material in a standard report folder with the brads inserted through the back cover only, with the heads on the outside.

Report Outline

The material should be arranged in the following order:

I. Title page
II. Introduction
III. Method of investigation
  A. Procedure
  B. Diagrams

IV. Results
  A. Data
    1. Nameplate data of equipment
    2. Observed and calculated data
  B. Sample calculations
  C. Curves
V. Analysis of results
VI. Questions

(Not more than one of the above six divisions should be included on a single page. Omit Roman numerals.)

I. Title Page

On this page should appear the name of the school, the course number and title, the date performed, the date submitted, the name of the student reporting, and the names of coworkers. This page may be omitted if the form printed on the report folder includes these items.

II. Introduction

The introduction should be a concise statement setting forth the aim and scope of the investigation.

III. Method of Investigation

A. *Procedure.*—In this section a general description of the procedure should be given. It should be comprehensive but brief. The enumeration and detailed description of routine mechanical operations and their sequence—such as closing switches, reading instruments, turning knobs, and so forth—should in general be avoided. However, when a specific method of mechanical operation is necessary to assure the validity or accuracy of the test data, it is important that the essential details be included in the description.

B. *Diagrams.*—Each diagram should have a figure number, and should be referred to in the text material by that number. Each figure should have a descriptive title. Small diagrams may be included in the body of the description, or several may be drawn on one separate sheet if they do not crowd the page. Standard symbols should be used.

IV. Results

A. *Data.*—The first item under results should be the nameplate data, or equivalent identification, of the apparatus tested.

The original observed data and the calculated data should be presented in tabular form. If the observed data require corrections, these should be made before tabulation. Instrument identification numbers and ranges need not be copied from the original laboratory data sheet.

B. *Sample calculations.*—This section should consist of a sample of a complete calculation of each type involved in the determination of calculated data and the solution of problems. When a succession of calculations is required in order to reach a final result, the same set of observed data should be used in carrying through the successive sample calculations; i.e., the same sample figures that are selected from a data column should be used in all calculations involving that set of data.

C. *Curves.*—All curve sheets should conform to the following specifications:

1. Use "twenty to the inch" coordinate paper, 8¼ x 11 inches, for rectangular plots.
2. Plot in the first quadrant where only one quadrant is needed.
3. In general, make the axes intersect within the second part of the paper. Leave the curve sheet margins blank.
4. Plot the independent variable as abscissa and the dependent variable as ordinate.
5. In general, start the scale of the dependent variable, but not necessarily the scale of the independent variable, at zero.
6. Choose scales that are easy to use and that do not allow points to be plotted to a greater accuracy than that justified by the accuracy of the data.
7. Indicate points plotted from data by visible dots or very small circles.
8. Draw a smooth average curve through the plotted points except in cases in which discontinuities are known to exist. Use a French curve in drawing the curves.
9. Place a title containing all pertinent information on each curve sheet. The title should be lettered or typed. Label the axes and show the units in which they are marked.
10. Draw only related curves on the same sheet.
11. Insert curve sheets in the report so that they can be read from the bottom or right side.
12. Use ink for everything on the sheet except the curves themselves; these should be drawn with a colored pencil.

V. Analysis of results

The analysis of results is the most important section of the report. As the word "analysis" implies, it should be a complete discussion of the results obtained.

Part of the discussion should deal with the accuracy or reliability of the results. It is suggested, where applicable, that this section consist of a careful treatment of the effect on the results of the following: (1) Errors resulting from the necessity of neglecting certain factors because of physical limitations in the performance of the test, (2) errors in manipulation, (3) errors in observation, and (4) errors in instruments.

An important part of the discussion should be a comparison of the results obtained with those which would reasonably have been expected from a consideration of the theory involved in the problem. Whenever the theory is apparently contradicted, the probable reason should be discussed.

When results are given in graphic forms as curves, the shape of each curve should be carefully explained. Such an explanation should state the causes for the particular shape the curve may have.

Any original conclusions drawn as a consequence of the laboratory procedure and a study of the results obtained should be included in this section.

VI. Questions

In this section should be included the answers to any questions given as a part of the test.

Sample Laboratory Report

Experiment No. 3

A 213, Statistics and Quality Control
Unit IV - Control Charts

References:

Grant, E. L., Statistical Quality Control
Freedman, Rudolph and Movshin, J., Basic Training Manual on Statistical Quality Control

Objectives:

1. To analyze a typical industrial frequency distribution of measurements taken from similar machined parts.
2. To construct an x and R control chart.
3. To interpret the control chart in terms of the process.
4. To calculate the upper and lower control limits.

Procedure:

1. Take twenty samples of five successive pieces from the same process at one-hour intervals and record the measurements on a tally form.
2. Compute the average x and the range R for each sample.
3. Compute the grand average of the averages x and the average range R .
4. Compute the control limits and construct control charts for x and R.

   Note.--Use Appendix I in your manual to obtain the 3-sigma factors.

Questions:

1. Analyze the control chart with the purpose of suggesting any tool changes or machine adjustment. Is the process in control? Is there indication of a steady change in the average? Are there any measurements outside the control limits?

   Can you recognize any characteristic signs indicating assignable and chance cause variations? Is this a rational method of subgrouping? Why or why not?

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Mechanical Technology

Production Major

Course - A 213, Statistics and Quality Control

Experiment No. 3

Title:

Statistical method of analysis of a process

Name: John Doe Date: 11/26/62

Experiment No. 3

Introduction

In order to describe frequency distributions certain single numbers are used to tell things about the entire distribution. Such a number is called a statistic. The following statistics might be used to describe this frequency distribution.

1. Average or mean. This is the level or central tendency of the process and is denoted by $\bar{X}$ for individual measurements or $\bar{\bar{x}}$ for group measurements.
2. Range. This is the spread or dispersion of the process and is denoted by R for individual measurements or R for group measurements.

who The objectives of this laboratory assignment are to learn the use of a ~~tenth~~ micrometer, to calculate the range and the average of the measurements, and to plot and to analyze control charts. ?

These measurements were taken in the inspection laboratory on machined parts that were processed with?in close tolerance limits on a manually operated cylindrical grinder. Each sample represents a total of 150 pieces produced between regular sampling intervals.

Experiment No. 3

Procedure:

Twenty successive samples of five pieces from the same process were measured and their dimensions were recorded on a tally sheet. A one-inch micrometer,

Sp. caliberated to one ten thousanth was used. To expedite Sp

the necessary calculations only the fourth figure was recorded.

Then the average and range for each sample group was determined and from these values the grand average of the average measurements and the average range was computed. Then control charts for the averages and the ranges were constructed and the group averages plotted.

CONSTRUCTION OF $\bar{X}$ & R CONTROL CHART

GR.	MEASUREMENTS (X)					SUM	$\bar{X}$	R
1	2	0	1	0	1	4	.8	2
2	3	0	2	2	1	8	1.6	3
3	3	1	1	2	3	10	2.0	2
4	6	4	4	1	3	18	3.6	5
5	3	4	1	1	1	10	2.0	3
6	2	3	1	3	5	14	2.8	4
7	4	3	2	2	3	14	2.8	2
8	0	0	5	4	3	12	2.4	5
9	3	1	1	1	1	7	1.4	2
10	2	1	2	5	1	11	2.2	4
11	2	0	4	1	1	8	1.6	4
12	1	2	1	0	2	6	1.2	2
13	4	5	1	3	7	20	4.0	6
14	4	3	2	2	0	11	2.2	4
15	1	5	1	1	2	10	2.0	4
16	3	0	3	1	2	9	1.8	3
17	1	1	0	3	0	5	1.0	3
18	3	2	2	3	2	12	2.4	1
19	4	0	2	1	1	8	1.6	4
20	1	1	2	3	3	10	2.0	2
							41.4	65

$\bar{\bar{X}}$ = 2.07

$\bar{R}$ = 3.25

NOTE

$$\bar{\bar{X}} = \frac{\bar{X}_1 + \bar{X}_2 --- \bar{X}_m}{m}$$

WHERE $\bar{X}_1, \bar{X}_2 ---- \bar{X}_m$ ARE THE AVERAGES OF THE SAMPLES, AND m IS THE NUMBER OF SAMPLES

$$\bar{R} = \frac{R_1 + R_2 --- R_m}{m}$$

WHERE $R_1 + R_2 --- R_m$ ARE THE RANGES OF THE SAMPLES, AND m IS THE NUMBER OF SAMPLES

CONTROL LIMITS FOR $\bar{X}$ CHART, n= 20

$\bar{\bar{X}} \pm A_2 \bar{R}$

2.07 ± .58 x 3.25 OR 2.07 ± 1.8850

UCL IS 2.07 + 1.89 = 3.96

LCL IS 2.07 − 1.89 = .18

CONTROL LIMITS FOR R CHART

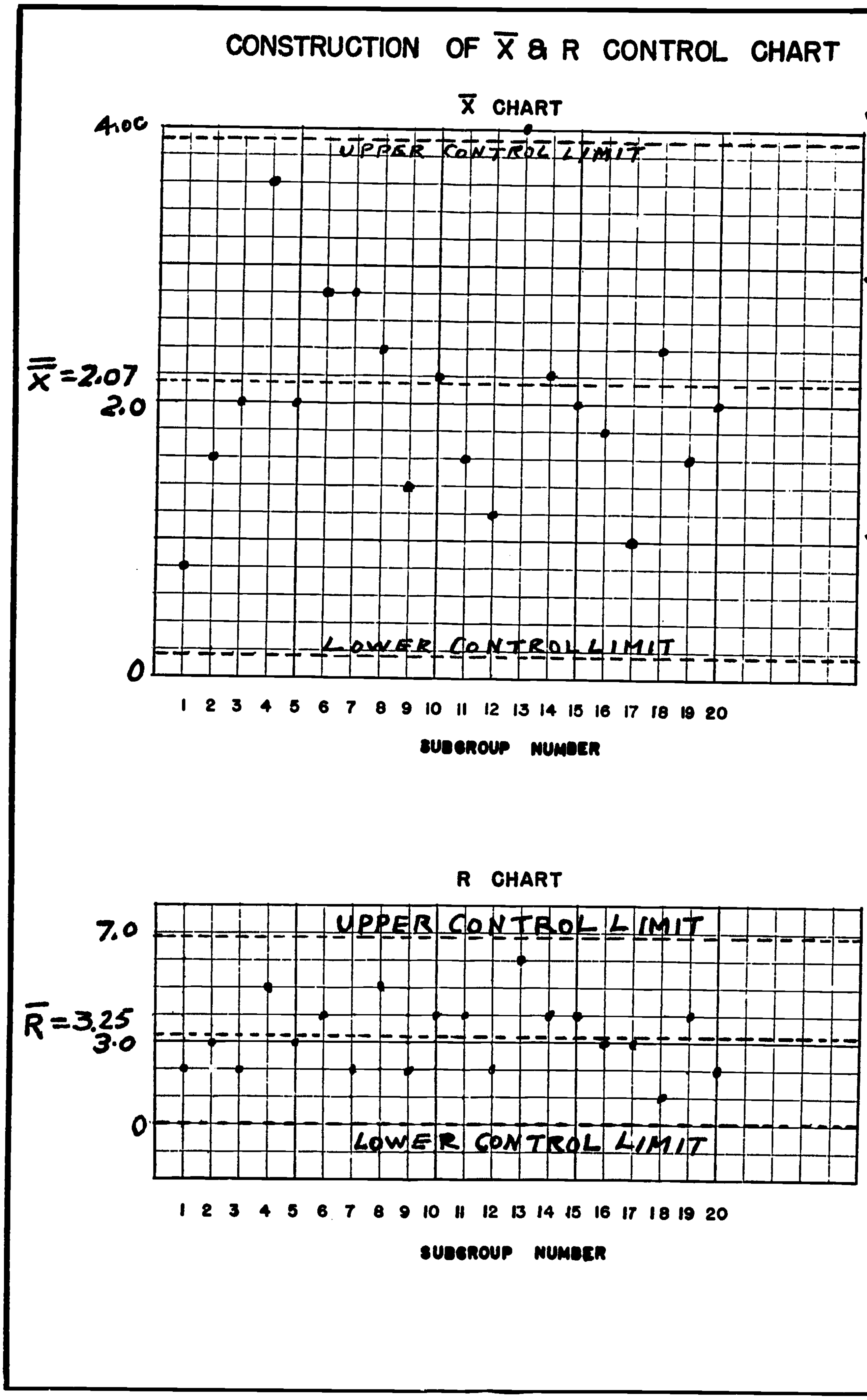
UCL IS $D_4 \bar{R}$

UCL IS 2.11 x 3.25 = 6.86

LCL IS $D_3 \bar{R}$

LCL IS 0 x 3.25 = 0

WS-3A



according To your plotted values each square represents .2, Consequently your center line for $\overline{\overline{X}}$ is too high.

Experiment No. 3

ANALYSIS OF REPORT AND CONCLUSIONS

The control chart for the averages of the twenty sample groups shows a rather uniform distribution, although there seems to be a tendency to hold more constantly below the center line. The upper area of the control chart shows a greater spread in values between the center line and the upper control limit. Because no two pieces can be identical, this spread in values can be considered as due to chance causes and are accepted as resulting from a particular process. Only one point falls outside the control limits. This occurs on the high side of the control chart. A single point outside the control limits does not appear to be harmful but, as it was pointed out, any point falling outside the control limits is due to some assignable cause and corrective measure must be taken.

V.G.

In this case the single point does become significant when considering the fact that it is the average value of a small sample taken from a lot size of 150 pieces produced between each sampling interval. It seems highly improbable that a single sampling could produce all the bad pieces in the lot. Therefore a safe conclusion is to assume that the process at this point is definitly out of control and corrective action should be taken.

Sp.

Does operator performance enter into this picture? How would you suggest a more reliable method of inspection?

Instruction Units

Teaching Guide

Sample 1

DP 113, MANUFACTURING PROCESSES 1
TOPIC: Division V. Powder Metal and Cermets
LECTURE TIME: One 55-minute period
OUTSIDE STUDY: 1 hour (minimum)
REFERENCE:

Begeman, "Manufacturing Processes," Fourth Edition, Pages 145–157
Schaller, "Engineering Manufacturing Methods," Pages 45–50

LECTURE OUTLINE:

1. General Introduction
   (a) Mechanical production of powder
      (1) Machining
      (2) Crushing
      (3) Milling
      (4) Graining
      (5) Shotting
      (6) Atomizing
   (b) Physical production of powder—condensation
   (c) Chemical production of powder
      (1) Reduction of metal ores by gas
      (2) Precipitation
   (d) Electrical production of powder
2. Processing Methods
   (a) Size selection
   (b) Lubrication materials
   (c) Mixing equipment
   (d) Shaping powder
      (1) Conventional OBI
      (2) Hydraulic
      (3) Rotary
   (e) Dies used
   (f) Sintering
      (1) Ovens
      (2) Liquid salts
      (3) Molten metals
3. Application
   (a) Bonding
   (b) Appliances
   (c) Coatings
   (d) Machine parts
   (e) Others

ASSIGNMENT FOR NEXT LECTURE PERIOD: Campbell, "Principles of Manufacturing Materials and Processes," Chapter 2, pages 9–39. Schaller, "Engineering Manufacturing Methods," Chapter 29, pages 530–546.

Sample 2

D 205, BASIC MECHANICS
TOPIC: Division V. Slider-Crank Mechanisms
LECTURE TIME: One 55-minute period
LABORATORY TIME: Four 2-hour periods
OUTSIDE STUDY: 3 hours (minimum)
REFERENCE: Church, A. H., "Kinematics of Machines," 5th Edition, Chapter 4, pages 50–86; Chapter 5, pages 87–101

VISUAL AIDS:

1. Model of slider-crank mechanism
2. Model of shaper mechanism

LECTURE OUTLINE:

1. Sliding block linkage
   (a) Use of slider-crank mechanism
   (b) Piston velocity—graphical method
      (1) Polar curve of piston velocity
      (2) Velocity-displacement curve
      (3) Velocity-time curve
   (c) Characteristics of piston motion
   (d) Connecting rod effect
   (e) Piston acceleration—graphical construction
   (f) Piston velocity—analytical method
   (g) Piston acceleration—analytical method
2. Quick-return motion
3. Shaper mechanism
4. Fixed block linkage

ASSIGNMENT FOR NEXT LECTURE PERIOD:

Reading Assignment.—Church, A. H., "Kinematics of Machines," 5th Edition, Chapter 6, pages 103–113. Cam displacement diagrams.

Problem Assignment.—Plot displacement diagrams in Problem 1, pages 138–139. Answer questions in Problem 2, page 139. Work Problem 3, page 139.

Laboratory I

D 205, BASIC MECHANICS
TOPIC: Division V. Slider-Crank Mechanisms: Crank-Driven Quick-Return Motion
EQUIPMENT REQUIRED: Standard drafting room equipment
SUPPLIES REQUIRED: Standard drafting supplies
REFERENCE: Church, A. H., "Kinematics of Machines," 5th Edition, Problem 15, Page 280, Plate 13

PROCEDURE: Use size "C" tracing paper. Read the statement of the problem in the text and proceed as follows: Draw the quick-return motion shown in Plate 13. The driving crank 2 has a length of 3¾ in. and rotates clockwise at 240 rpm. The driven slider 6 is to have a stroke of 16 in., and the time ratio of advance to return is to be 2:1.

1. Draw the mechanism as shown with the block 6 at the left end of its stroke. Find the length of lever 4 necessary to give the proper stroke and time ratio.
2. Draw a skeleton diagram of the mechanism as indicated by the dashed lines in the figure, with crank 2 at 45° with the vertical position.
3. Locate all instant centers for the mechanism in the position specified in paragraph 2.

4. By use of instant center 0_{26}, determine the instantaneous velocity of 6. Represent the velocity of pin M on the driving crank by a line 2 in. long.
5. By use of instant centers 0_{24} and 0_{41}, determine graphically the velocity of 6 and see that it checks with the value obtained in paragraph 4. SCALE: ½ inch = 1 inch
6. Plot the velocity-displacement curve for the forward and return stroke of the sliding block 6 to a scale of 1 inch equal to 10 feet per second. SCALE: ½ inch = 1 inch
7. On separate paper plot the following:
   - Polar velocity diagram
   - Velocity-time curve
   - Acceleration-displacement diagram
   - Acceleration-time diagram
8. Calculate and construct graphical scales for velocity and acceleration.

   Calculate the linear velocity of crankpin for given angular velocity. Show by vector to a scale indicated in step 4.

   Show graphically the linear velocity of sliding block 6 when crank arm is in vertical or 0° position as well as in the 45° position shown and also in 90°, 135° and 180° positions. Follow the directions given in step 6.

   Show all calculations on a separate sheet, not on the drawing.

B. Instructional Facility Suggestions

A Statement of Principles

THIRTY YEARS AGO every professional engineering curriculum had shop and drafting courses. Today these courses have been displaced by new subject matter considered more necessary to an engineer's education. Engineering education has systematically eliminated courses designed to teach production methods and techniques and has added course work in engineering analysis and design.

However, in the total production process someone still must be familiar with production methods and machinery, and someone has to work on the drafting board to transform the creative idea to a specific design for economic production. It is in these areas that technically trained personnel can utilize the training which the graduate engineer no longer gets. They assume the contact with the skills of production which the engineer has surrendered.

Technical personnel engaged in mechanical design or production must be familiar with production methods and drafting practices, both of which require an understanding of the operations, capacities, and limitations of machine tools and equipment. The designer should be able to make final detail drawings and to write specifications of parts to be produced, while production personnel should be able to make drawings for plant layouts.

The shop work in a technical course is not the same as that which is usually given in vocational education for skill training. The technical worker must become acquainted with the machine or process, and there is no better way to do this than to see and operate the machines and equipment. The educational programs in this publication are centered around the metal trades. The student should have access to and, wherever possible, some experience with the metal working equipment found in machine shops, welding shops, and foundries. The courses *DP 113 Manufacturing Processes I* and *DP 133 Manufacturing Processes II* contain outlines of this work.

It should be pointed out again that the objective of the technical student is not to attain a skill but to get the broadest experience he can with as many different types of equipment as possible. Therefore, the shop is used as a laboratory in which he moves from one situation to another as rapidly as he gains knowledge of what a machine can do and what its limitations are.

In this light it immediately becomes obvious that the laboratory for technical students must contain a variety of machines rather than a number of machines of one type. The work the student carries out will not be designed to acquire a skill but to illustrate the productivity, functions, and limitations of machines. Since the student should be familiar with some machines which only industry can afford, he will have to supplement his laboratory experiences and classroom information with trips to industrial installations.

Technical personnel design production units that can be made by machines. They must thoroughly understand the various production methods, the machines involved, and the capacities of these machines in order to make decisions involving accuracy as well as factors of cost, production, and durability.

Laboratory experiences as well as classroom instruction should be supplemented by visual aids, visits, and demonstrations. Thus it may be advantageous to illustrate thermal welding or the tapping of high pressure pipelines by demonstration or by visiting and observing industrial installations of automatic or programed machines.

The mechanical technology student must have laboratory experience in strength of materials and in metallurgy. It is possible to provide laboratory experience for both these subjects in one area. (See sample layout.) The student's activities in strength of materials and metallurgy laboratories provide technical knowledge that is basic in mechanical design. Such knowledge should include familiarity with industrial equipment and procedures. Beyond this, the student must have the opportunity to confirm principles. Thus, while in industry hardness is determined largely in one manner, it is well in the training situation to have as many methods as possible available to illustrate

principles and to compare methods. There should be enough laboratory work stations to enable each student to use each piece of equipment.

One exception to the general rule of emphasizing principles rather than skills is in the drafting courses of the mechanical design option. The language of the designer is graphic; it must be skillfully reproduced; it requires well-defined drafting ability. For this reason the drafting room should simulate industrial conditions as nearly as possible.

The ideal drafting room should contain large drafting tables with a full work station for each student. Approximately half the tables may be equipped with parallel edges and the other half with drafting machines.

Blackboards should extend across the front of the room. The white chalk board is desirable, since projections of films or material from an overhead projector may be made directly on it. One side of the room should have low storage areas with bulletin boards above for display of materials. The room should contain storage facilities; if the reproduction room is adjacent to the drafting room, the upper part of the wall between them can be of glass to enable the drafting teacher to have visual supervision of the class at all times.

The front of the drafting room should have a large table for the instructor to serve as a place for materials used in demonstration. At some place in the room, preferably adjacent to the teaching area, there should be enough open shelving to hold the machines and parts to be used as examples of design.

The floor should be of a material restful to the feet. The lighting should not be entirely natural, and artificial lighting should be of high intensity at drawing board height. If fluorescent lighting is used, care should be taken that it does not give polarized light.

As seen from the equipment list for drafting, the room should contain all the equipment and aids that one would expect to find in an industrial situation. In this room the student is expected, particularly in the advanced stages of the curriculum, to acquire the marketable skills of the entry job. At the completion of the training period he should be able to assume a position in industry with the least amount of adjustment.

All equipment should be selected with job objectives in mind. Every principle should be illustrated with an application and, where the skills of the entry job are involved, the situation in the school should simulate those of industry as nearly as practicable. Where possible, consideration should be given to the possible dual use of facilities if more than one technology is involved.

Equipment and Supplies

Drafting Laboratory

EQUIPMENT

Quantity	Description	Estimated cost
12	Drafting tables—3' x 4'; parallel ruling unit; metal based; dust cover	$1,600
12	Drafting tables—3' x 5'; metal based; dust cover	1,600
12	Drafting machines—24" arms with assorted scales (at least two different makes)	1,500
24	Drafting stools	525
1	Reproduction machine	275
2	Blueprint filing cabinets—5 drawers with base and cap, 30" x 42"	400
2	Filing cabinets for teachers	100
1	Overhead projector	150
24	Sets of drawing instruments and limited numbers of auxiliary items such as beam compasses	750
1	Demonstrator slide rule—7 feet	25
6	Assorted slide rules to demonstrate types used in industry	150
24	Triangular architect's scales	60
24	Triangular engineer's scales	120
24	Triangular mechanical engineer's scales	120
24	Flat scales—assorted	90
24	Sets of triangles	80
24	T squares	96
24	Protractors	10
	Assorted curves and templates	50
1	Cutting board	50
4	Lettering guide sets	40
1	Electric erasing machine	30
24	Bench brushes	50
2	Trimming shears 12"	15
	Engineering, machinists, standards, testing handbooks	200
	Other reference books	200

Supplies

Quantity	Description	Estimated cost
	Tracing paper	$50
	Drawing paper	100
	Tracing cloth	20
	Reproduction paper and supplies	70
	Assorted graph paper, orthographic, isometric and oblique sketching paper and pads, coordinate sheets, lettering guide sheets, etc	50
	Pencils, erasers, erasing shields, thumb tacks, masking tape, ink, etc	50

Metals Laboratory

Equipment

Quantity	Description	Estimated cost
1	Gas furnace with blower, torch lighter and pyrometer (range 0–2,400° F.)	$1,200.00
2	Salt pots with pyrometer (range 0–2,000° F.)	800.00
3	Gas fired blast furnaces with pyrometer (range 0–3,000° F.)	1,000.00
1	Cyanide pot	400.00
1	Certain curtain electric furnace with indicating controller potentiometer system 0–3,000° F	1,400.00
1	Heavy-duty electric furnace with recording potentiometer	1,500.00
1	Electric tempering furnace with electric controls (range 0–1,000° F.)	1,200.00
1	Electric furnace with pyrometer (range 0–2,600° F.)	900.00
1	Tempering oven (range 0–1,000° F.)	400.00
1	Heavy-duty multiple unit electric oven with potentiometer (range 0–2,000° F.)	1,100.00
1	Electric hot plate 12" x 18"	50.00
1	Pedestal grinder (1" x 8" x 1")	200.00
1	Gas furnace (7" x 12" x 5")	300.00
2	Quenching tanks (portable)	200.00
4	Rockwell hardness testing machines	$3,600.00
1	Brinell hardness testing machine	1,400.00
1	Shore scleroscope	275.00
1	Impact machine	1,450.00
1	Magnaflux unit 0–3,000 A output	3,000.00
1	Testing machine with recorder and attachments	11,000.00
1	Torsion tester	4,500.00
1	Bench type testing machine	2,700.00
1	Industrial X-ray machine and controls	6,000.00
1	Cut-off machine (bonded wheel)	300.00
1	Bench grinder with diamond wheels (6" dia.)	360.00
1	Belt grinder (horizontal)	125.00
2	Centermet presses 1¼" capacity	850.00
1	Metallograph	8,000.00
1	Electro polisher	500.00
1	Two-stage specimen polishing table	500.00
1	Grinder	100.00
2	Metallurgical microscopes	850.00
	Print roller Print box Developing Tanks	100.00

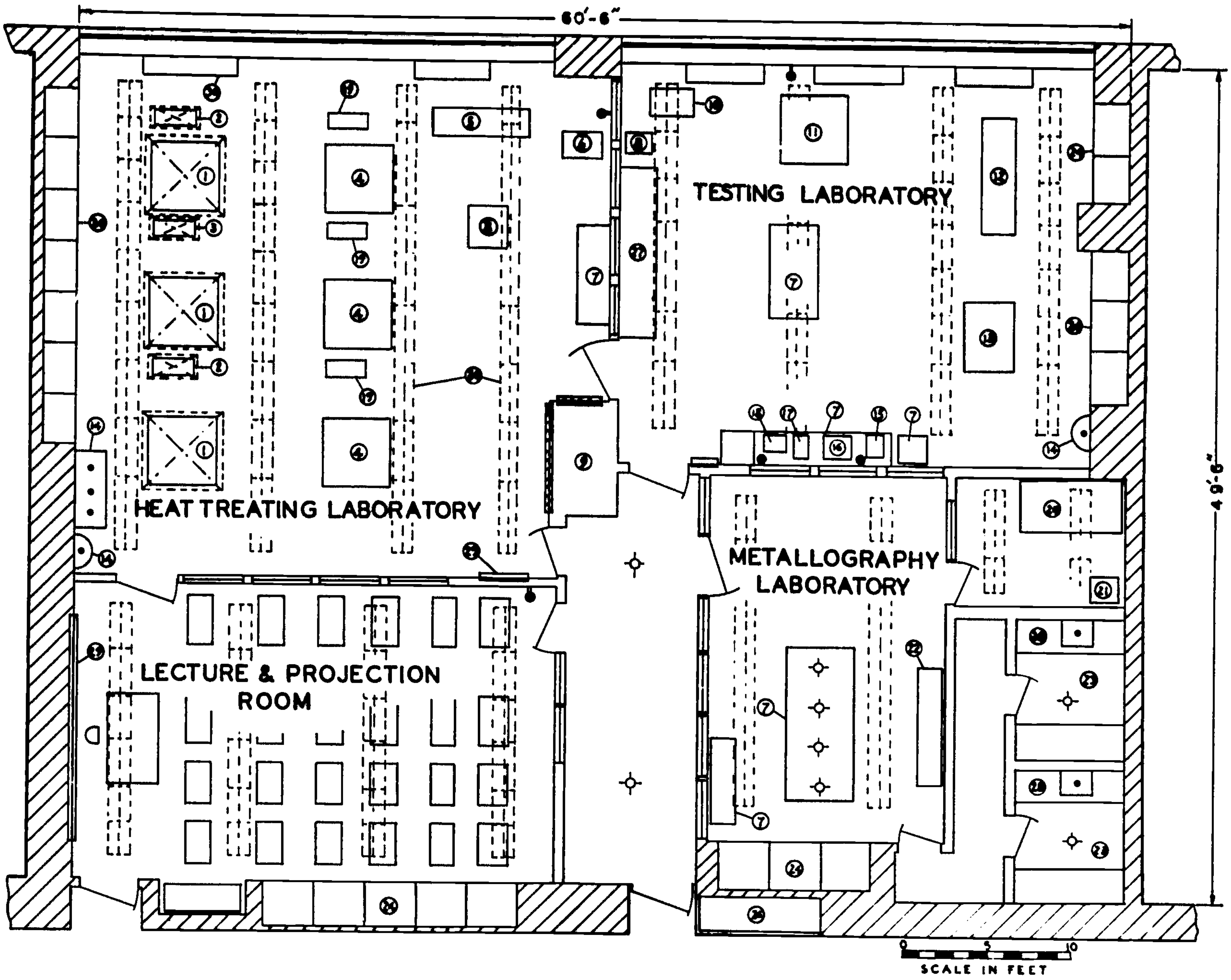
Tooling

Quantity	Description	Estimated cost
1	Dial indicator 1/10,000	36.00
	Assorted wrenches and heat treating tongs	65.00
2	Hacksaw frames	6.50
1	0–1" micrometer	16.50
1	0–1" thread micrometer	26.00
3	Sledges (2–#, 1–11#)	8.50

Supplies

Quantity	Description	Estimated cost
	Miscellaneous—Acids, alcohol, bakelite powder, carburizing compound, chisels, emery cloth, files, magnaflux powder, film, polishing powder, thermometers, recording paper, hacksaw blades, ferrous and nonferrous specimens, cut-off wheels, etc	1,200.00

Metals Laboratory



1. Gas furnaces with exhaust hoods
2. Salt pot with exhaust hood
3. Cyanide pot with exhaust hood
4. Electric furnace
5. Screened workbench
6. Pedestal grinder
7. Workbench
8. Tempering oven
9. Service cabinet
10. Impact machine
11. Magnaflux testing machine
12. Tension testing machine
13. Industrial X-ray
14. Sink
15. Cutoff machine
16. Pedestal grinder with diamond wheels
17. Horizontal belt grinder
18. Bench grinder
19. Quenching tanks—portable
20. Two-stage polishing machine
21. Electro-polisher
22. Metallograph
23. Photographic developing room
24. Storage cabinets
25. Exhibit case
26. Fluorescent lighting
27. Hardness testing equipment bench
28. Developing tanks
29. Chalk board
30. Heating equipment