VOLUME XX NUMBER 50

BULLETIN

OF

THROOP POLYTECHNIC INSTITUTE

APRIL, 1911

CATALOGUE NUMBER

PUBLISHED FOUR TIMES EACH YEAR: IN JANUARY, APRIL, JULY, AND OCTOBER

BY

THROOP POLYTECHNIC INSTITUTE
PASADENA, CALIFORNIA

ENTERED AT THE POST OFFICE, PASADENA, CAL., UNDER ACT OF CONGRESS, AS MAIL MATTER OF THE SECOND CLASS

Bulletin

of

THROOP POLYTECHNIC INSTITUTE

This is the official quarterly publication of the Institute. The annual volume comprises:

ALUMNI NUMBER (January), containing alumni papers, a list of the alumni, and such items regarding the same as may be of general interest.

CATALOGUE NUMBER (April), containing general information regarding the Institute, outlines and descriptions of courses of instruction, and faculty and student lists.

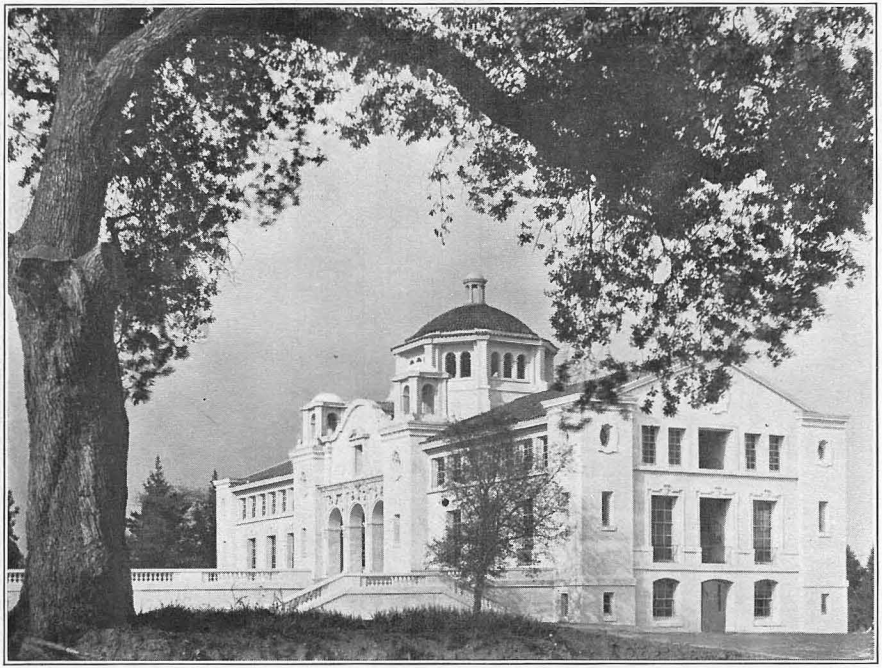
COMMENCEMENT NUMBER (July), containing an account of the Commencement exercises and addresses, announcements with regard to changes in and additions to the Faculty, and other notes of special interest pertaining to affairs of the Institute.

THE PRESIDENT'S ANNUAL REPORT (October), and such items regarding the same as may be of general interest.

Supplementary numbers and circulars are issued whenever necessary.

Address all communications to the

Secretary of the Faculty.



PASADENA HALL

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THROOP POLYTECHNIC INSTITUTE
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Theodore Roosevelt at Throop Institute

March 21, 1911

"I hail the fact that in America we are now establishing schools with the object of repeating what has been done in Germany. . . . I believe that the most important work for us in America to-day, in the way of education, is to train our people vocationally—to train men so that they can do the most efficient possible work in the vocations they undertake; and I also regard it as of the utmost importance to train the exceptional man on a purely cultural basis. In other words, I want to see institutions like Throop turn out perhaps ninety-nine of every hundred students as men who are to do given pieces of industrial work better than any one else can do them; I want to see those men do the kind of work that is now being done on the Panama Canal and on the great irrigation projects in the interior of this country—and the one hundredth man I want to see with cultural scientific training."

Contents

Annals for the Year 1910-'11

September 26—First Assembly: Invocation, the Rev. Dr. Everett L. Conger; Greeting from the Board of Trustees, Judge Charles J. Willett; Response from the Student Body, Mr. Herbert S. Wood; Address, President Scherer; subject: "Making our Own Precedents."

October 2—The President's Reception to the Students.

October 7—President Scherer presents to the Board of Trustees his Second Annual Report.

October 21—The President's Reception to the Trustees and Faculty.

November 7—Assembly Address by Dr. Webster Merrifield, former President of the University of North Dakota; subject: "Ideals."

November 10—Organization of Students' Section of the American Institute of Electrical Engineers.

December 1—Meeting of the Southern California Science and Mathematics Association at the Institute.

December 9—Lecture to the Senior Class by Mr. N. G. Felker, Clerk of the Pasadena Board of Education; subject: "Business Organization."

December 16—Piano Recital in Throop Lecture Courses by Miss Alice Coleman, assisted by Mr. Frank Patterson; subject: "Classic Forms in Pianoforte Composition."

January 11—Lecture to the Senior Class by Mr. Seward A. Simons; subject: "Insurance."

January 13—Lecture in Throop Lecture Courses by Mr. Ferdinand Ellerman of the Carnegie Solar Observatory; subject: "Photography as Applied to Astrophysical Work, and the Use of Ray Filters."

January 23—Assembly Address by President Harry A. Garfield of Williams College; subject: "The Value and Dignity of Creative Work."

January 27—Lecture to the Senior Class by Mr. W. S. Wright; subject: "Stocks and Bonds."

January 30—Assembly Lecture by Judge Charles G. Neely; subject: "The Making of the Constitution."

February 3—Piano Recital in Throop Lecture Courses by Miss Coleman, assisted by Mr. Harry Clifford Lott; subject: "Development of Modern Lyric and Dramatic Forms."

February 6—Assembly Lecture by Judge Neely; subject: "The Implied Powers of the Constitution."

February 9—Special Lecture in the Throop Courses by Mr. Joseph Fels; subject: "The Single Tax."

February 10—Lecture to the Senior Class by Mr. A. M. Harrah; subject: "Probate Law."

February 10—Lecture in Throop Lecture Courses by Professor William Conger Morgan of the University of California; subject: "The Secrets of Flame."

February 13—Assembly Address by Professor Morgan; subject: "The Scientific Training of Engineers."

February 15—Lecture to the Senior Class by Mr. N. W. Bell; subject: "Real and Personal Property."

February 17—Lecture in Throop Lecture Courses by Dr. Arthur S. King of the Carnegie Solar Observatory; subject: "The Spectroscope in Modern Science."

February 17—Lecture to the Senior Class by President M. G. Potts of the Potts Business College; subject: "Negotiable Papers."

February 20—Assembly Lecture by Judge Neely; subject: "Police Powers of the State."

February 24—Lecture in Throop Lecture Courses by Mr. Walter S. Adams of the Carnegie Solar Observatory; subject: "Some Applications of Spectrum Analysis to the Study of the Stars."

February 27—Assembly Lecture by Mr. J. B. Lippincott, Assistant Chief Engineer of the Los Angeles Aqueduct Bureau; subject: "California Hydrography."

March 6—Assembly Lecture by Mr. Ezra F. Scattergood, Electrical Engineer for the Los Angeles Aqueduct Construction Company; subject: "The Testing of Power Plants."

March 10—Lecture in Throop Lecture Courses by Mr. Walter McClintock; subject: "The Black-

feet Indians of the Plains and Rocky Mountains."

March 13—Assembly Address by Dean George A. Damon, Managing Engineer of the Arnold Company; subject: "The Report on the Pittsburg Transportation Problem."

March 14—Special Assembly Address by Mr. Jacob Riis; subject: "American Citizenship."

March 14—Lecture in Throop Lecture Courses by Mr. Jacob Riis; subject: "The Making of an American."

March 21—Lecture in Throop Lecture Courses by Mr. Theodore Roosevelt; subject: "A Zoölogical Trip through Africa."

March 22—Special Assembly Address by Mr. Theodore Roosevelt.

March 31—Special Assembly Address by Mr. Elihu Thompson, Electrical Engineer; subject: "The Origin of Electrical Engineering in America."

April 7—Lecture in Throop Lecture Courses by Professor Charles Zueblin; subject: "The Twentieth Century City."

April 10—Assembly Address by Mr. Kempster B. Miller, Consulting Engineer; subject: "The Work of the Telephone Engineer."

April 14, 15—Laboratory Exhibits.

April 17—Assembly Lecture by Mr. J. B. Lippincott; subject: "The Los Angeles Aqueduct."

April 24—Assembly Lecture by Mr. Ezra F. Scattergood; subject: "Safeguarding Life in Engineering Practice."

May 1—Assembly Address by Mr. S. S. McMeen, Consulting Engineer; subject: "Automatic Telephones." Special Assembly Address by Senator Charles W. Bell; subject: "Sacramento."

May 8—Assembly Address by Mr. J. H. Francis, Superintendent of Los Angeles City Schools.

May 15—Assembly Address by Mr. Mark Keppel, Superintendent of Schools for Los Angeles County.

May 17—Assembly Lecture by Mr. J. B. Lippincott; subject: "The Los Angeles Aqueduct," continued.

May 22—Assembly Address by Mr. W. H. Housh, Principal of the Los Angeles High School.

May 24—Assembly Lecture by Mr. Ezra F. Scattergood; subject: "Utilization of Waterflow in the Los Angeles Aqueduct."

May 29—Assembly Address by Professor LeRoy D. Ely, Principal of Pasadena High School; subject: "Saracenic Architecture and Decoration."

June 4—Baccalaureate Sermon by Rev. Robert Freeman.

June 5—Commencement: Address by Senator Lee C. Gates.

The Charter

AMENDED ARTICLES OF INCORPORATION OF THROOP POLYTECHNIC INSTITUTE

(Formerly Throop University)

Know all men by these presents, that we the undersigned, all of whom are residents and citizens of the State of California, have this day voluntarily associated ourselves together for the purpose of forming a Corporation under the laws of the State of California.

And we hereby certify, FIRST—That the name of said corporation shall be Throop Polytechnic Institute.

SECOND—That the purpose for which it is organized is to establish, maintain and operate an institution of learning embracing the different departments, or colleges, of higher education, including those of the various professions; and to provide for all who may wish an inexpensive, but liberal, thorough and practical education.

THIRD—That the place where the institution is to be conducted is Pasadena, California.

FOURTH—That the number of its Trustees shall be fifteen, and the names and residences of the first Board of Trustees are as follows:

A. G. Throop, Pasadena, Cal.; P. M. Green, Pasadena, Cal.; J. W. Scoville, Pasadena, Cal.; E. L. Conger, Pasadena, Cal.; Enoch Knight, Los Angeles, Cal.; W. L. Hardison, Santa Paula, Cal.; C. H. Keyes, Riverside, Cal.; James H. Tuttle, Minneapolis, Minn.; Jeanne C. Carr, Pasadena, Cal.; Louise T. W. Conger, Pasadena, Cal.; J. D. Yocum, Pasadena, Cal.; E. E. Spalding, Pasadena, Cal.; W. E. Arthur, Pasadena, Cal.; Charles F. Holder, Pasadena, Cal.; George H. Deere, Pasadena, Cal.

The Board of Trustees shall, as soon as organized, so classify themselves that three of their number shall go out of office every year, but thereafter the Trustees shall hold office for five years.

A majority of said Board shall not belong to any one religious denomination or sect, and the institution shall be maintained and administered as an undenominational and non-sectarian school.

FIFTH—The name of the only person who has yet subscribed money or property to assist in founding said University, is A. G. Throop, who has subscribed the amount of Two Hundred Thousand Dollars.

H. H. Markham, H. W. Magee, J. C. Michener, W. U. Masters, J. S. Dodge, Geo. H. Bonebrake, Delos Arnold, Lionel A. Sheldon, T. P. Lukens, E. F. Hurlbut, T. S. C. Lowe, P. M. Green, F. C. Howes, Milton D. Painter, A. G. Throop

In witness whereof, we have hereunto set our hands this 12th day of September, one thousand eight hundred and ninety-one.

STATE OF CALIFORNIA, }
COUNTY OF LOS ANGELES, } ss.

On this seventeenth day of September, in the year one thousand eight hundred and ninety-one, before me, E. T. Howe, a Notary Public in and for said County of Los Angeles, personally appeared.

H. H. Markham, H. W. Magee, J. C. Michener, W. U. Masters, J. S. Hodge, Geo. D. Bonebrake, Delos Arnold, Lionel A. Sheldon, T. P. Lukens, E. F. Hurlbut, T. S. C. Lowe, P. M. Green, F. C. Howes, Milton D. Painter, A. G. Throop,

Known to me to be the persons whose names are subscribed to the within and annexed instrument, and acknowledged to me that they executed the same.

In witness whereof, I have hereunto set my hand and affixed my official seal, at my office, in the City of Pasadena, County of Los Angeles, the day and year above written.

E. T. HOWE,

Notary Public in and for Los Angeles County, Cal.

(Seal)

STATE OF CALIFORNIA, }
COUNTY OF LOS ANGELES, } ss.

We, Norman Bridge, President, and David Heap, Secretary of the Board of Trustees of Throop Polytechnic Institute (formerly Throop University) do hereby certify that the foregoing is a full, true and correct copy of Articles of Incorporation of Throop Polytechnic Institute as the said Articles are now amended; that the same were duly amended by a majority vote of the Board of Trustees of said Corporation, with the written consent of two-thirds of the incorporators and in accordance with directions contained in the last will and codicil of Amos G. Throop, deceased.

In witness whereof, we have set our hands and affixed the seal of the said Corporation this twenty-ninth day of July, 1897.

(Signed) NORMAN BRIDGE, President,
DAVID HEAP, Secretary of the Board of Trustees of Throop Polytechnic Institute.

Calendar for the Year 1911-'12

July 11, 1911....Annual Meeting of the Board of Trustees

September 11, 1911
Consideration of Applications for Admission[1]

September 20, 1911.....Beginning of the Academic Year

September 20-22, 1911.....Entrance Examinations

September 23 and 25, 1911
Registration (8 A. M. to 4:30 P. M.)

September 26, 1911
Beginning of Regular Instruction (8 A.M.)

November 30—December 2, 1911.....Thanksgiving Recess

December 21, 1911—January 1, 1912.....Christmas Recess

January 2, 1912.....Resumption of Instruction (8 A.M.)

January 29—February 2, 1912.....Semester Examinations

February 3, 1912..Examinations for Removal of Conditions

February 3, 1912.....End of First Semester

February 5, 1912
Registration for Second Semester (8 A.M. to 4:30 P.M.)

February 6, 1912.....Resumption of Instruction (8 A.M.)

February 22, 1912 .....Washington's Birthday (Holiday)

March 25-30, 1912.....Spring Recess

June 3-7, 1912.....Semester Examinations

June 9, 1912.....Baccalaureate Sunday

June 10, 1912 ..... Commencement

June 10, 1912.....End of the Academic Year

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[1]Applications for admission, with credentials, should be mailed to the Secretary of the Faculty as early as possible; in any event they should be on file a sufficient length of time before the opening of the Institute to permit of communication with the applicants, who otherwise might be seriously inconvenienced in beginning their work.

Founder

Hon. Amos G. Throop

Born at De Ruyter, New York, July 22, 1811. Died at Pasadena, California, March 22, 1894

The Board of Trustees

(Arranged in the order of seniority of service)

Term Expires

Everett L. Conger, D.D. 1912
44 So. Orange Grove Ave.

Norman Bridge, A.M., M.D. 1914
Los Angeles

Mrs. Clara B. Burdette 1915
891 So. Orange Grove Ave.

Hiram W. Wadsworth, A.B. 1911
437 So. Orange Grove Ave.

James H. McBride, M.D. 1915
489 Bellefontaine St.

S. Hazard Halsted 1912
90 No. Grand Ave.

Arthur H. Fleming 1914
1003 So. Orange Grove Ave.

Charles J. Willett, A.M. 1913
352 No. Los Robles Ave.

George E. Hale, Sc.D., LL.D. 1911
South Pasadena.

Charles W. Gates 1912
South Pasadena.

James A. Culbertson 1911
235 No. Grand Ave.

Henry M. Robinson 1915
195 So. Grand Ave.

William H. Vedder 1914
Prospect Park.

John Wadsworth 1913
685 E. Colorado St.

Officers of Administration

OFFICERS OF THE BOARD

Norman Bridge ..... President
Arthur H. Fleming ..... First Vice-President
Charles J. Willett ..... Second Vice-President
Everett L. Conger ..... Third Vice-President
Edward C. Barrett ..... Secretary
William H. Vedder ..... Treasurer
Charles J. Willett ..... Attorney
James A. B. Scherer ..... President of the Institute

EXECUTIVE COMMITTEE

Norman Bridge ..... Chairman ex-officio
James A. Culbertson — **S. Hazard Halsted**
Arthur H. Fleming — **Charles J. Willett**

FINANCE COMMITTEE

A. H. Fleming — **Charles W. Gates** — **James A. Culbertson**

OFFICERS OF THE FACULTY

James A. B. Scherer ..... President
George A. Damon ..... Dean of Engineering
B. F. Stacey ..... Secretary of the Faculty
Wallace K. Gaylord ..... Registrar

OTHER ADMINISTRATIVE OFFICERS

Charles F. Holder ..... Director of the Museum
475 Bellefontaine St.

M. Gladys Brownson ..... Librarian
214 South Lake Ave.

Edward C. Barrett ..... Business Agent
920 Delmar St.

Inga Howard ..... President's Secretary
1126 Division St.

Officers of Instruction

PROFESSORS

JAMES A. B. SCHERER, A. M., Ph. D., LL. D.

President

A. B., Roanoke College, 1890; A. M., Roanoke College, 1895; Ph. D., Pennsylvania College, 1897; LL. D., University of South Carolina, 1905. Teacher of English in the Imperial Government's Middle School at Saga, Japan, 1892-1897; Professor of Oratory and History in the Theological Seminary at Charleston, S. C., 1898-1904; President of Newberry College, S. C., 1904-1908.

415 South El Molino Avenue.

GEORGE ALFRED DAMON, B. S. in E. E.

Dean of Engineering

B. S. in Electrical Engineering, University of Michigan, 1895. Managing Engineer of the Arnold Company since 1905.

399 South Mentor Avenue.

ROYAL W. SORENSEN, B. S. in E. E.

Professor of Electrical Engineering

B. S. in Electrical Engineering, University of Colorado, 1905. Associated with General Electric Co., Schenectady, N. Y., and Pittsfield, Mass., 1905-1910.

46 North Wilson Avenue.

LUCIEN HOWARD GILMORE, A. B.

Professor of Physics

A. B., Leland Stanford, Jr., University, 1894. Acting Assistant, Department of Physics, Leland Stanford, Jr., University, 1894-1895; Graduate work in the University of Chicago.

649 Galena Avenue.

BENJAMIN FRANKLIN STACEY, A. M.

Professor of History and Political and Social Science

A. B. and B. D., Lombard College, 1898; A. M., University of Arizona, 1903. Scholar, University of Chicago, 1898-1900; Fellow, same, 1900-1901; Investigator of Institutions for the Chicago Bureau of Charities, 1899-1900; Instructor in Economics and Philosophy, University of Arizona, 1902-1904.

274 North Raymond Avenue.

CLINTON KELLY JUDY, B. A.

Professor of the English Language and Literature

A. B., University of California, 1903; B. A., Oxford University, 1909.

289 North Los Robles Avenue.

FREDERICK ERNEST BECKMANN, Ph. D.

Professor of French, German, and Spanish

A. B., University of Chicago, 1897; Ph. D., University of Chicago, 1900; Graduate work at Goettingen, Paris, and Madrid. Instructor in the Romance Languages, University of Minnesota, 1899-1904; Instructor in French and English, Deutsche Schule, Antwerp, 1904-1906.

1145 Chicopee Street.

HERBERT BOARDMAN PERKINS, S. B.

Associate in Civil Engineering and Mathematics[1]

S. B., Massachusetts Institute of Technology, 1874; Graduate work in the University and Polytechnikum, Munich, Germany; the University of Geneva, Switzerland, 1880-1882; and the University of California, 1886-1888. Professor of Mathematics and Astronomy, Lawrence University, 1878-1880 and 1882-1886; Professor, University of Southern California, 1890-1892.

45 South Fair Oaks Avenue.

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[1]The John Wadsworth Chair.

ROBERT EDGAR FORD, B. E. E., E. E.

Associate in Mechanics and Hydraulics

B. E. E. and E. E., University of Minnesota. Associated with Electric Manufacturing Co., Minneapolis, 1895; Consulting steam and electrical engineer, Minneapolis, 1896-1897; Graduate work in the University of Minnesota, 1900.

137 South Madison Avenue.

CHARLES H. KICKLIGHTER, B. S. in M. E.

Associate in Mechanical Engineering

B. S. in Mechanical Engineering, Georgia School of Technology, 1902; Graduate work in the University of Wisconsin. Adjunct Professor of Mathematics, 1902-1903, and Assistant Professor of Physics, 1903-1905, Georgia School of Technology; Director of Engineering, Newberry College, S. C., 1905-1909; Professor of Mechanical Engineering, University of Florida, 1909-1910.

46 North Wilson Avenue.

WALLACE KENDALL GAYLORD, S. B.

Associate in Chemistry

S. B., Massachusetts Institute of Technology, 1893. Graduate work in the University of California.

75 North Hudson Avenue.

HARRY CLARK VAN BUSKIRK, Ph. B.

Associate in Mathematics

Ph. B., Cornell University, 1897.

723 North Michigan Avenue.

INSTRUCTORS

WALTER WILLIAM MARTIN[1]

Instructor in Wood Working

Normal Arts Department, Throop Polytechnic Institute, 1900.

973 Locust Street.

CLARENCE ARTHUR QUINN[1]

Instructor in Forging

Normal Department, Stout Manual Training School, 1897.

515 North Marengo Avenue.

JAMES O'NEIL BARNWELL, B. S.[1]

Instructor in Pattern Making and Machine Shop Practice

B. S., University of Missouri, 1909.

153 Harkness Avenue.

SPECIAL LECTURERS[2]

JOSEPH BARLOW LIPPINCOTT, C. E.

Lecturer on California Hydrography and the Distribution of Water Supply

C. E., University of Kansas; Assistant Chief Engineer of the Los Angeles Aqueduct Bureau.

EZRA FREDERICK SCATTERGOOD, M. M. E.

Lecturer on the Testing of Power Plants and the Utilization of Municipal Water Supplies in Developing Power

M. M. E., Cornell University; Electrical Engineer for the Los Angeles Aqueduct Construction Bureau, and the Los Angeles Power Bureau.

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[1]Associated also with Throop Academy.

[2]A list of speakers in the Throop Lecture Courses, Assembly Exercises and class-room work is given on pages 4–8.

Introductory

In beginning his lecture in the science series of the Throop Lecture Courses last March, Mr. Theodore Roosevelt said:

"I am glad to speak here before the representatives of a great technical school, one of those schools the development of which has meant more for the pre-eminent efficiency of Germany in the modern European world than any other one thing. Germany owes its phenomenal standing in the industrial world more than any thing else to the fact that it has trained its young men towards instead of away from their life work. I hail the fact that in America we are now establishing schools with the object of repeating what has been done in Germany. . . . I believe that the most important work for us in America to-day, in the way of education, is to train our people vocationally—to train men so that they can do the most efficient possible work in the vocations they undertake; and I also regard it as of the utmost importance to train the exceptional man on a purely cultural basis. In other words, I want to see institutions like Throop turn out perhaps ninety-nine of every hundred students as men who are to do given pieces of industrial work better than any one else can do them; I want to see those men do the kind of work that is now being done on the Panama Canal, and on the great irrigation projects in the interior of this country—and the one hundredth man I want to see with the kind of cultural scientific train-

ing that will make him and his fellows the matrix out of which you can occasionally develop a man like your great astronomer, George Ellery Hale."

Although Mr. Roosevelt was probably not aware of the fact, Mr. Hale himself has been largely responsible for the projection of the new educational policies of Throop Polytechnic Institute, and it is interesting to note that in his initial address on this subject (in February, 1908), he embodied the very ideas that appeal so forcibly to Mr. Roosevelt, who, in his recent Throop lecture, continued as follows:

"The foundation of our success as a country must be laid in the work of the men to whom the word 'science' means the business application of scientific principles. That I not merely admit, but upon that fact I insist. But, in addition to that—our civilization will always be one-sided, it never will reach the highest standard, until we also produce in abundance the men who will do the non-remunerative work of science, who love learning for its own sake, and who have the gift of expression; in other words, who have the gift of description to present to the minds of others pictures of what they themselves have seen. We need men like the great astronomer of whom I have spoken, men like Fairfield Osborn in New York, men who have the gift of scientific imagination. . . . The great historian is necessarily a man of imagination, and, however accurate he may be, he cannot be, in the broadest sense, truthful, unless, like Gibbon, Macaulay, and others, he has the power to visualize to himself what he has found in the past,—unless he has the power not merely to visualize it himself, but to put it down in

words so that his readers can visualize it also. We need scientifically to have the same type of men."

It will now be interesting to compare with these words the remarks of Professor Hale, when invited by the Throop Board of Trustees in 1908 to indicate the best educational policies to be followed in the proposed reorganization of the Institute—policies adopted then and in force now, as indicated in the following pages. Mr. Hale said:

"Here, two causes have conspired to further the development of our industries and our foreign commerce: the native ingenuity and aggressiveness of the American, and the immense natural resources of the country. These have off-set, in large degree, the painstaking research of the less inventive German and have overcome the prestige so long enjoyed by England in foreign markets. But, as natural resources show signs of ultimate exhaustion, and as engineering methods advance from their earlier stage to that condition where the highest efficiency is the chief element of success, the research methods of the German must receive more attention. We understand already that a thorough technical training is required by an engineer. But the full appreciation of the importance of research has come only in some of the greatest of American industries. For the same reason that the General Electric Company now maintains a great research laboratory, in which new methods are developed and old processes are improved, it may confidently be predicted that this and similar examples will be followed in the future by manufacturing establishments, great and small, throughout the United States.

"Here in California the conditions and the need for technical education are unsurpassed. In no part of the world is electrical engineering so highly developed, especially in the transmission of power from great distances. In hydraulic engineering, we are facing to-day an undertaking of enormous magnitude. Eastern technical schools are far removed, those of the north insufficiently developed and also too remote. Under such conditions, and with the advantages afforded by climate, by the immediate neighborhood of mountains where water-power can be developed and experimental transmission lines installed, who can deny that there is a place in Pasadena for a technical school of the highest class?

"In developing such a school, we must provide the best of instruction and the most perfect equipment that modern engineering offers. But in laying stress upon the practical aspects of the problem we must not forget that the greatest engineer is not the man who is trained merely to understand machines and to apply formulae, but is the man who, while knowing these things, has not failed to develop his breadth of view and the highest qualities of his imagination. No great creative work, whether in engineering or in art, in literature or in science, has ever been the work of a man devoid of the imaginative faculty. In seeking to develop the school, therefore, let us not forget that our prime object should be to graduate men capable of conceiving vast projects, not less than men whose abilities are limited to the power of executing them. With the rapid development of engineering in all directions, and the constant increase in the amount of detailed information

placed before the student, the difficulty of securing the requisite breadth of view is serious. In most technical schools this problem has not been solved, and the opportunity stands open for Throop to devise and carry into effect a broad scheme of education which may give proper recognition to all sides of the engineer's life."

In the winter of 1908 a curriculum was devised applying these principles to the departments of Electrical, Mechanical, and Civil Engineering. In the following spring the newly elected President of the Institute accompanied Mr. Hale on a visit to the leading technical schools of America and Europe, for the purpose of testing and improving this curriculum—which is now in force at the Institute, under the direction of a carefully chosen Faculty.

To complete the reorganization of the Institute, the Board of Trustees took drastic measures towards lifting the school to its new educational plane, through the segregation of all students except those of a true collegiate standing. At the beginning, 195 pupils were segregated into a new institution of their own, now in successful operation as a polytechnic elementary school. In 1910 the Institute separated itself from 288 more, of a still higher grade, who became the constitutents of a separate institution known as Throop Academy, which is now being merged with the new Polytechnic High School supported by the City of Pasadena. The Institute opened this first year in its new quarters with only thirty students left in its classes, being resolved to live up to its standards.

Meanwhile, with faith in the future, a physical

equipment had been provided in keeping with high plans and ideals. A generous friend purchased and gave to the corporation a spacious and beautiful campus near the southeastern boundaries of the city, flanked by the mountains, for the accommodation of a group of new buildings. The first of these, "Pasadena Hall," erected through the liberality of a score of citizens, and dedicated in June, 1910, is a majestic building comprising 800,000 feet of cubic contents, containing sixty-two rooms, and fitted with the most complete modern equipment. A second building, containing the steam and hydraulics laboratories, was occupied with the opening of the new institution last September. A committee representing the ladies of Pasadena is now well advanced with a plan for the erection of a beautiful auditorium and art gallery as an adjunct to Pasadena Hall. In the spring of 1911 the Endowment has been enriched by gifts from four friends in the sum of $250,000. Such, in a word, has been the rapid development of the "great technical school" which Mr. Roosevelt so warmly commended.

Pasadena is not only one of the most beautiful of cities, with a climate of unapproached equability and healthfulness, but it is also noted for the morality, refinement, and culture of its citizens. Being purely a residential town, ten miles from the factories and marts of Los Angeles, it is surrounded by safeguards and privileges that fit it for the guardianship of youth. Saloons are prohibited by charter. Boys under age are shut out by statute from questionable places of amusement, such as poolrooms, of which there are few. A curfew law keeps

younger boys off the streets at night. It is known as "the city of churches and schools." It is also frequently called "the most beautiful town in the world." To be surrounded by an atmosphere of purity and beauty is no hindrance to a training in utility.

The school is broadly Christian, but a clause of its charter has for many years provided that a majority of the Board of Trustees "shall not belong to any one religious denomination or sect, and the institution shall be maintained and administered as an undenominational and non-sectarian school."

Its social ideal is embodied in one word: Democracy. Whatever savors of class or caste it abhors. Every encouragement is given to students of limited means who wish to labor in order to learn.

The Public Works Scholarship Fund, described on page 37, is a unique and successful example of coöperation between a school and a municipality for mutual benefit and in aid of deserving young men. The Olive Cleveland Loan Fund is described on page 37.

General Information

REQUIREMENTS FOR ADMISSION

All Applicants for Admission must give evidence of good moral character and of ability to take the courses shown in the catalogue. Students from other institutions must present letters of honorable dismissal, together with statements showing in detail the amount and character of previous training. Entrance to the Freshman year of the Engineering courses may be secured either through certificate from an approved school or the College Entrance Examination Board; or by examinations conducted by the Institute. Entrance forms will be furnished on request[1].

All Applicants for the Engineering Courses must show at least fifteen units of preparatory work; each "unit" representing one year's work in an approved school at the rate of five recitation periods weekly. The table of requirements is as follows:

English[2]	3
Mathematics	4
German, French, Spanish[3], or Latin[3]	2
United States History and Government	1
Physics	1
Chemistry	1
Other subjects[4]	3
Total	15

[1]Applicants are advised to enroll at the beginning of the Academic year, as many of the subjects continue throughout both semesters and may not be entered in the middle of the year.

[2]Applicants offering either three or four years of any foreign language, or two years in each of two foreign languages, may enter with three years of English.

[3]Engineering students not offering French or German must study one or the other of these languages for three years at the Institute.

[4]These may include any secondary subjects, not indicated above, which meet the approval of the Faculty of the Institute.

Approved Schools are those that maintain a full four years' course of high-school work and are accredited by the New England College Entrance Certificate Board, or the North Central Association of Colleges and Secondary schools, or by colleges and universities of recognized standing at which the entrance requirements are equivalent to those at the Institute.

The College Entrance Examination Board may be addressed at "Post Office Sub-station 84, New York City." This Board's entrance examinations for 1911 will be held June 19 to 24, 1911. Applications for examination at points east of the Mississippi River, also at Minneapolis, St. Louis, and other points on the Mississippi River, must be received by the Secretary of the Board at least two weeks in advance of the examinations, that is, on or before Monday, June 5, 1911. Applications for examination elsewhere in the United States or Canada must be received at least three weeks in advance, that is, on or before Monday, May 29, 1911; and applications for examination outside of the United States and Canada must be received at least five weeks in advance, that is, on or before Monday, May 15, 1911. A fee of five dollars is charged for each candidate examined by the Board in the United States or Canada, and fifteen dollars for each one examined elsewhere. An additional fee of five dollars is charged for each application received later than the dates above mentioned.

Applicants not admitted by certificate are required to pass entrance examinations. These examinations,

both for admission and advanced standing, are held at the Institute at 8 a.m., on Wednesday, Thursday and Friday, September 20, 21 and 22, 1911; and on Monday, February 3, 1912. Applicants who find it necessary to take such examinations should notify the Secretary of the Faculty well in advance of these dates so as to allow ample time for correspondence. Those whose papers come too late for full consideration may be seriously inconvenienced in beginning their work. Special examinations will not ordinarily be given. In exceptional cases, however, such examinations may be arranged by the Committee on Registration, but a special fee of two dollars will be charged for each subject in which an examination is taken. Entrance examinations should ordinarily not exceed two hours in length.

Applicants failing to receive credits for the fifteen units necessary, may be admitted conditionally to the engineering courses, provided they are not deficient in more than two units, and provided, also, that both of these units be not in the same subject. Conditions, however, must be removed by the beginning of the Sophomore year; preferably on the last day of the preceding semester.

Applicants for advanced standing must either take examinations at the Institute or furnish certificates of credit satisfactory to the Institute authorities, including the professors in charge of the departments concerned.

Application forms for advanced standing may be had on request, and should be returned to the Secretary of the Faculty as promptly as possible.

The forms may be filled out by the applicants, but should be duly certified by the proper officials of the institutions in which the work was done.

Applicants for the General Courses will ordinarily be required to show at least thirteen units of preparatory work, and to carry at least thirty units of work in the Institute.

DESCRIPTION OF REQUIRED COURSES

The following outlines of courses will indicate the kind and amount of work acceptable to the Institute in the subjects required for admission. Information regarding requirements in other subjects may be secured from the Secretary of the Faculty.

English.—Examinations will presuppose thorough acquaintance with the following works or their equivalent. For convenience the subjects have been arranged in groups corresponding to the four years of preparatory work:

Group 1: Lady of the Lake; Ivanhoe and Alhambra; the best Ballads, Heroic Lays and Poems of Nationality, in all about 1500 lines; Classical and Teutonic Mythology (about 200 pages, covering approximately the material of sections 16-61, 65-67, 70-100, 104-107, 111-125, 132-164 of Gayley's Classic Myths). (1 unit)

Group 2: Merchant of Venice, Julius Cæsar, Ancient Mariner, Tam O'Shanter, Deserted Village, Cotter's Saturday Night, Prisoner of Chillon, Horatius, Fortunes of the Republic, Lowell's Commemoration Ode. (1 unit)

Group 3: Silas Marner, Vicar of Wakefield, Passing of Arthur, Launcelot and Elaine, Gareth and Lynette, Vision of Sir Launfal, L'Allegro, Il Penseroso, Comus, Gray's Elegy, Eve of St. Agnes, Rape of the Lock, Alexander's Feast, Emerson's American Scholar and Fortunes of the Republic, Lincoln's Gettysburg Address and Second Inaugural. (1 unit)

Group 4: Orations and Arguments: Burke's Speech before the Electors at Bristol; Macaulay's First Speech on the Reform Bill; Webster's Reply to Hayne. Essays: Emerson's Compensation and Self-Reliance. Chaucer's Prologue to the Canterbury Tales; Shakespeare's Macbeth; Milton's Lycidas and Sonnets II, XVI, XIX, XXII; Wordsworth's Tintern Abbey, Ode on the Intimations of Immortality, and Ode to Duty; Shelley's The Cloud, and The Skylark; Browning's Rabbi Ben Ezra, and Andrea del Sarto; Arnold's Forsaken Merman and Rugby Chapel; Tennyson's Œnone. (1 unit)

German.—Examinations presuppose the ability to translate easy German prose and verse at sight; an accurate knowledge of the most important elements of grammar, embracing especially inflections, word-order, and the essentials of syntax, as also the ability to appreciate the force of prefixes and suffixes; the ability to translate easy prose from English into German; the ability to make oral use of the German learned and to recognize German words and simple sentences when spoken. Careful attention should be given to pronunciation and accentuation, in order to insure the power to read German fluently and intelligently. (2 units)

French.—1. An accurate knowledge of the forms of the language, including the inflections, conjugations, and principal parts of verbs. Particular attention should be devoted to this part of the subject; constant drill in the verbal inflections, both written and oral, and dictation exercises of various kinds, are recommended. 2. The elements of syntax, such as the uses of the article, the personal pronouns, the subjunctive, the partitive constructions and the agreement of the participles. 3. The ability to turn easy English prose into French. 4. The ability to translate ordinary French into idiomatic English. 5. The ability to pronounce French correctly. It is believed that a fairly good pronunciation can be obtained in the fitting schools, if the necessary time is devoted to the subject. (2 units)

Spanish.—Elementary grammar, including a thorough knowledge of irregular verbs; ability to translate from ordinary Spanish into English and from English into Spanish. A correct pronunciation is insisted on. (2 units)

Latin.—The applicant should have such knowledge of the elements of Latin grammar as is offered in a standard Latin preparatory book. He should also have read at least four books of Cæsar or Nepos, or the equivalent, and should give satisfactory evidence of having had a thorough course in Latin composition. The Institute strongly recommends the study of Latin by those planning to take scientific work, as it not only facilitates the acquisition of the modern languages, but gives a better understanding of the various terms used in science.

Mathematics.—Many of the difficulties commonly encountered by engineering students are due to insufficient mathematical training. Freshmen should have at their command the fundamental principles of algebra, geometry, and trigonometry. To this end it is advised that the high-school course in mathematics be thoroughly reviewed just before entrance at the Institute.

Elementary Algebra: Fundamental operations, simple equations, factors, factor theorem, fractions, simultaneous equations, involution, evolution, irrational numbers, simple quadratic equations. (1 unit)

Higher Algebra: Theory of exponents, complex numbers with graphical representation, simultaneous quadratic equations, theory of quadratic equations, inequalities; ratio, proportion and variation; arithmetical, geometrical, harmonical, and other simple services; the binomial theorem for positive integral exponents, logarithmic calculations, determinants. Graphical methods and illustrations should be used in connection with the solution of equations. (1 unit)

Plane Geometry: In the teaching of Geometry stress should be placed upon accuracy of statement as well as upon strict reasoning. This end may be promoted by requiring original propositions to be written out in full in

a neat and attractive manner. Emphasis should be laid upon clear thinking as well as the acquirement of geometrical knowledge. The requirements in plane geometry include problems in mensuration of plane figures and original propositions, as well as the usual demonstrated theorems. The following topics are included: the general properties of plane figures; the circle, and the measure of angles; areas; regular polygons, and the measure of the circle. (1 unit)

Solid Geometry: The topics included are: relations of lines and planes to space; the properties of prisms; pyramids, cylinders, and cones; the sphere and spherical triangle; also, the mensuration of solids, and original propositions. (½ unit)

Trigonometry: This subject includes the general formulas of plane trigonometry; the theory of logarithmic tables; application to the numerical solution of triangles and of simple problems in heights and distances. (½ unit)

History and Government of the United States.—A knowledge of the outline of American History, and of the nature of Federal, State, and local government. This requirement represents three things: the regular use by the pupil of a text-book in history and a text-book in government; systematic reading of assigned references; and a note-book containing maps, concise topical outlines or summaries of the most important movements or institutions, notes on some of the reference reading, and a few carefully prepared brief papers with bibliographical notes. (1 unit)

Physics.—The equivalent of one year's work in the high school, including both laboratory and text-book work. It is preferred that at least one-half the time be given to laboratory work in which the students perform individually such experiments as are described in the better class of laboratory manuals. Accurate notes of the laboratory work should be kept. (1 unit)

Chemistry.—Besides the usual text-book and recitation work, each student should have a laboratory course in

which he performs the experiments for himself. Accurate notes of the laboratory work should be kept. The necessary amount of laboratory experience cannot be obtained in less than four hours a week for one school year, in addition to the class-room. It is preferred that the laboratory work be entirely devoted to illustration of the important facts and principles of general chemistry, rather than partly to analytical chemistry. (1 unit)

REGISTRATION AND SCHEDULE

Registration for the first semester will take place on September 23 and 25, 1911, and for the second semester on February 5, 1912, beginning at 8 a. m. A special fee of two dollars is charged for registration after these dates. All first semester students must register again for the second semester, irrespective of subject. A subject will not be assigned unless the officer of instruction in that subject is satisfied that the applicant is competent to undertake it. The schedule for each student is made out only by the representative of the Faculty designated for that purpose. No student shall be enrolled by the Registrar without a card endorsed by such representative. Each change of schedule shall be subject to such endorsement, and, after the first week of the semester, involves a fee of one dollar unless made at the suggestion of the Institute.

REGULATIONS AND DISCIPLINE

The following system of notation is used to indicate class standing: "A" denotes a grading of

from 85 to 100%, indicating that the record is very satisfactory; "B" from 70 to 84%, showing that the record is clear; "C" denotes a condition, including any grade below 70% and all deficiencies that may be made up without actually repeating the subject; "D" signifies failure, and that the subject must be repeated.

Every student is required to attend all class and Assembly exercises, and to satisfy the requirements in each of his subjects in such a way as the instructors may determine.

An instructor, with the approval of the President, may at any time exclude from his subject any student who, in his judgment, has neglected the work of the subject, and any student thus excluded shall be recorded as having failed in the subject from which he was excluded.

Undergraduates who fail of a passing grade in at least thirty units of duly registered work in any semester will be dropped from the roll of the Institute.

Final examination in any subject will be left to the discretion of the officer of instruction having the subject in charge. When examination is not to be given the instructor must so inform the Registrar at least ten days before the first regular examination day.

No student will be excused from assigned examination. If absent from examination without permission from the proper authority, he shall be regarded as having failed in the examination, but if absent with leave he will be considered as conditioned. A student who is reported as having failed in

examination, or who, after being conditioned, does not pass his re-examination for the removal of the condition, will be required to repeat every such deficient subject with the class next taking it, except in special cases, when he may be permitted to review the subject under an approved tutor. In any case he will be required to take the regular examinations of the year or half-year.

Prolonged leave of absence must be sought by written petition to the Faculty, and the student must indicate the length of time and the reasons for which absence is requested. In case of brief absences from any given exercise, arrangements must be made with the instructor in charge.

It is taken for granted that students enter the Institute with serious purposes and that they will cheerfully conform to such regulations as may be made by the Faculty. The moral tone of the Institute is exceptionally good, and cases requiring severe discipline seldom occur. Any conduct harmful to the moral atmosphere of the Institute will render a student liable to dismissal. Parents may at any time be asked to withdraw from the Institute students whose work is unsatisfactory by reason of lack of diligence. On the severance of his connection with any part of the work of the Institute, a student is required to return immediately all locker keys and other Institute property, and any such student may be excluded from the campus as soon as his affairs have been properly adjusted.

Disciplinary penalties involve the four grades of probation, suspension, dismissal, and expulsion. Probation indicates that the student is in danger of ex-

clusion, and that he is not permitted to represent the Institute on any public occasion. Suspension means exclusion for a definite period, with the presumption that the student's connection with the Institute will be ended by it. Expulsion, the highest academic censure, denotes final exclusion from the school.

Matters of final and severe discipline will be in the hands of the President and such other persons as he may designate. All instructors are authorized and directed to regulate conduct and correct disorder in the class-rooms and hall-ways, and on the campus. The following statement is emphatically endorsed: "For the conduct and character of its students a college assumes a far more intimate responsibility than a university. Toward mere thoughtlessness and exhuberance of animal spirits it will be lenient. But toward vice in its three dread forms, drunkenness, gambling, and licentiousness, it will exercise a severity unknown to universities. It will not ferret out evil by spies, nor cultivate the acquaintance of the scandalmongers of the town, nor encourage students to testify against each other, nor take unfair advantage of medical or quasi-medical information given in confidence. But though it fights fairly, it will fight these vices every chance it gets. When these evils come fairly and squarely to its attention, as when carried to excess they inevitably do, the school counts no cost too high, whether in removing students or alienating families and friends, to pay for keeping its moral atmosphere clean and wholesome."

SCHOLARSHIPS AND BENEFITS

Mr. William Thum, of Pasadena, has donated a fund known as the Public Works Scholarship Fund, for the purpose of providing employment to students in the various departments of municipal work. Under the provisions of this fund, students approved by the Faculty are employed in the Municipal Lighting Department, the Department of Streets, and a number of other departments, thereby gaining valuable experience in practical business and municipal affairs while earning their own tuition.

The Olive Cleveland Fund was donated by Miss Olive Cleveland, under an agreement which became effective upon her death in 1903, for the purpose of aiding students to obtain an education. The proceeds of this fund are loaned without interest to students who need such assistance. Applications for loans may be made to the President of the Institute, or to the Secretary of the Board of Trustees. Loans are authorized by the Executive Committee of the Board of Trustees upon recommendation of the President and the Committee of the Faculty having the matter in charge.

EXPENSES

Tuition is $150 a year, payable in two equal installments, one at the beginning of each semester. The only other fee is a diploma fee of $10. Locker rental is $3 a year, and the cost of books and stationery ranges from $15 to $25. Students are held re-

sponsible for any careless or willful destruction or waste of Institute property.

No reduction or refund is made to any student who may be suspended or expelled or who may leave school without a reason that shall be deemed valid by the Faculty Council; nor is any refund allowed for attendance equalling or exceeding three-quarters of a semester. All refunds are subject to a discount of 20%. No dormitories are maintained by the Institute, but a list of approved places where board and room may be obtained at from $25 to $40 a month may be found at the office of the Secretary of the Faculty. A few students "board themselves," but such a plan of living is not generally recommended; others secure board and lodgings in exchange for a few hours of daily labor. Many opportunities are found for self-support, besides those offered by the Public Works Scholarship Fund. (See Page 37).

Schedules of Courses

EXPLANATORY

The Institute confines its degrees to Electrical, Mechanical, and Civil Engineering. Students seeking a degree in Mining or Chemical Engineering, however, may take their first two years at the Institute, and then enter the third year class in Engineering colleges giving degrees in those branches.

The relationship of the several engineering courses is intimate. In the practical world it is impossible entirely to separate the engineering professions. They have much in common, and a man engaged in any one of them finds himself frequently confronted by problems and considerations pertaining to the others. Especially is this the case in the development, generation, and handling of power. In the modern electric power-plant, for example, problems in hydraulics, structural design, steam engines, turbines, and electrical generators constantly present themselves. Questions related to any one of these branches can be solved only with a thorough comprehension of certain conditions imposed by the others.

As engineering subjects have so much in common, and as all are grounded upon mathematics and the physical sciences, the courses during the first two years are practically identical for all branches. After this they diverge more or less, each laying particular emphasis on problems peculiar to itself. Yet even in these advanced courses, various engin-

eering subjects are taken in common, as illustrated in the following instances:

Electrical engineering students take courses in applied mechanics, materials laboratory, mechanical engineering design, steam engineering, mechanical laboratory, steam laboratory, surveying, hydraulics, and hydraulics laboratory.

Mechanical engineering students take courses in direct current machinery, alternating current machinery, electrical measurements, electrical laboratory, electrical engineering practice, surveying, hydraulics, and hydraulics laboratory.

Civil engineering students take courses in applied mechanics and mechanical laboratory.

General courses may be made up from the schedules upon consultation with the Secretary of the Faculty, but must comprise at least thirty units of work weekly. All of the essentials of a liberal education may be obtained in this way. (See the Index of Subjects on Page 51).

The term "prescriptive" denotes studies that may be assigned by the Faculty to the individual student according to his talents or his needs. For instance, students found to be deficient in English during their Freshman year may be advised to take "Special Composition" in the following year, even though they nominally complete the Freshman work in English, as required. On the other hand, those who show especial aptitude, for example, in the modern languages, or whose future work will be furthered by advanced acquaintance with them, may take one or more as "prescriptive" (with the approval of the

Faculty) after they cease to be required; that is to say, throughout the Junior and Senior years.

The "subject number" in the following tables refers to the description of subjects beginning on page 50.

The "unit" used in these schedules is a semester credit based on the sum of the hours required weekly by any given subject, including class work, shop or laboratory work, and preparation.

Each school year is divided into two semesters, beginning in September and February. The normal work of a semester amounts to 48 units, but when a subject continues throughout the year the units granted for any semester may not be counted toward graduation until the subject in question is completed. A total of 384 units is required for graduation.

ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING[1]

FIRST YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
I. FRESHMAN YEAR **1st Semester**					
Required					
English	410	3	0	3	6
French or German	433 or 443	3	0	4	7
Advanced Algebra	352	2	0	2	4
Computations	351	2	0	2	4
Chemistry	300	3	4	5	12
Mechanical Drawing and Descriptive Geometry.	460	1	4	1	6
Freehand Drawing	475	0	1	0	1
Shop Work	480	0	4	0	4
Shop Lectures	490	1	0	1	2
Prescriptive.					
Plane Trigonometry	350	3	0	3	6
Descriptive Geometry	470	2	3	2	7
Mechanical Drawing	465	0	3	0	3
General Biology	370	2	4	4	10
French[2]	430	3	0	4	7
German[2]	440	3	0	4	7
Gymnasium					
FRESHMAN YEAR **2nd Semester**					
Required					
English	410	3	0	3	6
French or German	433 or 443	3	0	4	7
Analytical Geometry	353	3	0	6	9
Chemistry	301	3	4	5	12
Mechanical Drawing and Descriptive Geometry.	460	1	4	1	6
Freehand Drawing	475	0	1	0	1
Shop Work	481	0	4	0	4
Shop Lectures	491	1	0	1	2
Prescriptive					
Spherical Trigonometry[3]	356	2	0	2	4
Elementary Analysis	357	2	0	2	4
Mechanical Drawing	465	0	3	0	3
General Bacteriology	375	2	4	4	10
French[2]	430	3	0	4	7
German[2]	440	3	0	4	7
Gymnasium					

[1]For Mining and Chemical Engineering, see page 39.

[2]Required for all students offering Spanish or Latin as an entrance language.

[3]Required of Civil Engineering students.

ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING

SECOND YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
II. SOPHOMORE YEAR					
1st Semester					
Required					
English	412	2	0	2	4
French or German	434 or 444	3	0	4	7
Differential Calculus	354	3	0	5	8
Physics	250	3	0	5	8
Physical Laboratory	251	0	4	0	4
Mechanism[1]	150	2	0	2	4
Mechanical Drawing	461	0	3	0	3
Shop Work[1]	482	0	4	0	4
Shop Lectures	492	1	0	1	2
Prescriptive					
French[3]	431	3	0	4	7
German[3]	441	3	0	4	7
Sociology	406	2	0	3	5
Special Composition	411	1	0	2	3
Spanish[2]	450	3	0	4	7
Quantitative Analysis	303	1	6	2	9
Surveying	200	3	6	3	12
SOPHOMORE YEAR					
2nd Semester					
Required					
English	413	2	0	2	4
French or German	434 or 444	3	0	4	7
Integral Calculus	354	3	0	5	8
Physics	252	3	0	5	8
Physical Laboratory	253	0	4	0	4
Mechanism[1]	150	2	0	2	4
Mechanical Drawing	462	0	3	0	3
Shop Work[1]	483	0	4	0	4
Shop Lectures	493	1	0	1	2
Prescriptive					
French[3]	431	3	0	4	7
German[3]	441	3	0	4	7
The Development of the State	398	2	0	3	5
Special Composition	411	1	0	2	3
Spanish	450	3	0	4	7
Quantitative Analysis	304	1	6	2	9
Surveying	200	3	6	3	12

[1]Civil Engineering students will substitute Surveying.

[2]Regular Sophomore students may substitute Spanish for French or German.

[3]Students finding it necessary to take French 430 and 431 or German 440 and 441, will then be required to take French 433 or German 443.

ELECTRICAL ENGINEERING

THIRD YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
III. JUNIOR YEAR **1st Semester**					
Required					
English	414	2	0	2	4
Development of European States	390	3	0	3	6
Theoretical and Applied Mechanics	160	4	0	6	10
Electricity and Magnetism	264	1	0	2	3
Electrical Measurements.	255	1	0	1	2
Electrical Measurements.	256	0	2	0	2
Direct Currents	100	3	0	5	8
Electrical Laboratory	101	0	3	1	4
Mechanical Laboratory..	180	0	6	0	6
Engineering Design....	463	0	3	0	3
Prescriptive					
Differential Equations...	355	2	0	4	6
French	435	2	0	3	5
German	445	2	0	3	5
Spanish	451	2	0	3	5
Contemporary History...	391	2	0	3	5
Current Periodicals.....	500	1	0	1	2
Natural Science.....					
JUNIOR YEAR **2nd Semester**					
Required					
English	415	2	0	2	4
Problems in American Government	396	3	0	3	6
Strength of Materials...	162	4	0	6	10
Hydraulics	230	2	0	3	5
Hydraulics Laboratory...	231	0	6	0	6
Elementary Alternating Currents	102	3	0	6	9
Electrical Laboratory....	103	0	6	0	6
Graphic Statics and Structural Design	161	0	5	0	5
Prescriptive					
French	435	2	0	3	5
German	445	2	0	3	5
Spanish	451	2	0	3	5
History of Science.....	380	2	0	2	4
Municipalities	397	2	0	3	5
Current Periodicals	500	1	0	1	2
Natural Science					

ELECTRICAL ENGINEERING

FOURTH YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
IV. SENIOR YEAR **1st Semester**					
Required					
English	416	1	0	2	3
Elementary Economics	400	2	0	3	5
Business Law and Accounting	405	2	0	2	4
Alternating Current Analysis	104	4	0	6	10
Electrical Laboratory	105	0	6	0	6
Steam Engineering	170	2	0	3	5
Surveying	249	1	2	2	5
Mechanical Laboratory	183	0	4	0	4
Prescriptive					
French	436	2	0	3	5
German	446	2	0	3	5
Electrical Communication	108	2	0	4	6
Current Periodicals	500	1	0	1	2
Natural Science					
SENIOR YEAR **2nd Semester**					
Required					
English	416	1	0	2	3
Industrial History of the United States	401	2	0	3	5
Business Law and Accounting	405	2	0	2	4
Electrical Engineering	106	4	0	6	10
Electrical Laboratory	107	0	3	0	3
Mechanical Laboratory	184	0	8	0	8
Thesis		0	0	12	12
Prescriptive					
French	436	2	0	3	5
German	446	2	0	3	5
Illumination and Distribution	109	2	0	4	6
Current Periodicals	500	1	0	1	1
Natural Science					

MECHANICAL ENGINEERING

THIRD YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
III. JUNIOR YEAR 1st Semester					
Required					
English	414	2	0	2	4
Development of European States	390	3	0	3	6
Theoretical and Applied Mechanics	160	4	0	6	10
Electricity and Magnetism	254	1	0	2	3
Direct Current Machinery	140	2	0	4	5
Mechanical Laboratory	180	0	6	0	6
Machine Design	151	3	0	3	6
Engineering Design	463	0	5	0	5
Prescriptive					
French	435	2	0	3	5
German	445	2	0	3	5
Spanish	451	2	0	3	5
Contemporary History	391	2	0	3	5
Current Periodicals	500	1	0	1	2
Natural Science					
JUNIOR YEAR 2nd Semester					
Required					
English	415	2	0	2	4
Problems in American Government	396	3	0	3	6
Strength of Materials	162	2	0	3	5
Electrical Engineering	142	2	0	4	6
Electrical Laboratory	141	0	3	0	3
Hydraulics	230	2	0	3	5
Hydraulic Laboratory	131	0	6	0	6
Machine and Engineering Construction Details	152	3	0	3	6
Graphic Statics and Structural Design	161	0	5	0	5
Prescriptive					
French	435	2	0	3	5
German	445	2	0	3	5
Spanish	451	2	0	3	5
History of Science	380	2	0	2	4
Municipalities	397	2	0	3	5
Current Periodicals	500	1	0	1	2
Natural Science					

MECHANICAL ENGINEERING

FOURTH YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
IV. SENIOR YEAR 1st Semester					
Required					
English	416	1	0	2	3
Elementary Economics	400	2	0	3	5
Business Law and Accounting	405	2	0	2	4
Steam Engineering	170	2	0	3	5
Industrial Electricity	144	2	0	3	5
Electrical Laboratory	143	0	3	0	3
Surveying	249	1	2	2	5
Hydraulic Motors	232	2	0	3	5
Mechanical Laboratory	182	0	8	0	8
Mechanical Engineering Design	464	0	3	0	3
Prescriptive					
French	436	2	0	3	5
German	446	2	0	3	5
Electrical Communication	108	2	0	4	6
Current Periodicals	500	1	0	1	2
SENIOR YEAR 2nd Semester					
Required					
English	416	1	0	2	3
Industrial History of the United States	401	2	0	3	5
Business Law and Accounting.	405	2	0	2	4
Power Plant Engineering	171	3	0	6	9
Mechanical Laboratory	184	0	8	0	8
Thesis		0	0	12	12
Prescriptive					
French	436	2	0	3	5
German	446	2	0	3	5
Illumination and Distribution	109	2	0	4	6
Current Periodicals	500	1	0	1	2
Natural Science					

CIVIL ENGINEERING

THIRD YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
III. JUNIOR YEAR 1st Semester					
Required					
English	414	2	0	2	4
Development of European States	390	3	0	3	6
Theoretical and Applied Mechanics	160	4	0	6	10
Mechanical Laboratory	180	0	6	0	6
Highway Engineering	201	1	0	2	3
Railway Surveying	202	3	3	3	9
Theory of Structures, Bridges, etc.	203	5	0	5	10
Sewerage, Septic tanks, etc.	204	2	0	3	5
Prescriptive					
Differential Equations	355	2	0	4	6
French	435	2	0	3	5
German	445	2	0	3	5
Spanish	451	2	0	3	5
Contemporary History	391	2	0	3	5
Current Periodicals	500	1	0	1	2
Natural Science					
JUNIOR YEAR 2nd Semester					
Required					
English	415	2	0	2	4
Problems in American Government	396	3	0	3	6
Strength of Materials	162	2	0	3	5
Hydraulics	230	2	0	3	5
Hydraulics Laboratory	231	0	6	0	6
Graphic Statics and Structural Design	161	0	5	0	5
Least Squares	358	2	0	3	6
Theory of Structures, Bridges, etc.	203	5	0	7	12
Prescriptive					
French	435	2	0	3	5
German	445	2	0	3	5
Spanish	451	2	0	3	5
History of Science	380	2	0	2	4
Municipalities	397	2	0	3	5
Current Periodicals	500	1	0	1	2

CIVIL ENGINEERING

FOURTH YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
IV. SENIOR YEAR **1st Semester**					
Required					
English	416	1	0	2	3
Elementary Economics	400	2	0	3	5
Business Law and Accounting	405	2	0	2	4
Water Supply and Hydraulics	206	3	3	6	12
Reinforced Concrete and Other Arches	207	2	0	4	6
Bridge Design	208	2	3	3	8
Hydraulic Motors	232	2	0	3	5
Prescriptive					
Surveying Instruments	249	1	2	2	5
French	436	2	0	3	5
German	446	2	0	3	5
Current Periodicals	500	1	0	1	2
Natural Science					
SENIOR YEAR **2nd Semester**					
Required					
English	416	1	0	2	3
Industrial History of the United States	401	2	0	3	5
Business Laws and Accounting	405	2	0	2	4
Railway Economics	209	1	0	2	3
Bridge Design	208	3	3	3	9
Engineering Specifications	210	2	0	2	4
Astronomy and Geodesy	211	4	0	5	9
Advanced Surveying	212	0	3	0	3
Thesis		0	0	9	9
Prescriptive					
French	436	2	0	3	5
German	448	2	0	3	5
Current Periodicals	500	1	0	1	2
Natural Science					

Description of Subjects and Equipment

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ELECTRICAL ENGINEERING

No attempt is made to acquaint the student with a multitude of unimportant details which soon become obsolete, but, on the other hand, no effort is spared to ground him well in the fundamental principles of magnetism, electricity, and the direct and alternating current machinery. With a working knowledge of these, and a training in habits of initiative and industry, the student should be well prepared to master quickly the details of new apparatus and new methods, to adapt himself readily to changing conditions and requirements, and to meet successfully the emergencies with which he is sure to be constantly confronted when he becomes an active engineer.

Continual attention is paid to the solution of carefully selected problems for the purpose of imbedding fundamental principles and developing the reasoning powers.

Lecture and text-book courses are accompanied by quantitative laboratory work.

Visits are occasionally made to the various electric light, power, and manufacturing plants of Los Angeles or vicinity, and men actively engaged as leaders in various lines of engineering are secured as lecturers.

100. Direct Currents.—Theory and practice of direct current machinery, armature windings, distribution and wiring, measuring instruments. Numerous problems are solved. Text: Elements of Electrical Engineering, Franklin and Esty, Vol. 1. Required of all Electrical Engineering students, first semester, Junior year. (8 units)

101. Direct Current Laboratory.—Calibration and uses of measuring instruments, analysis of characteristic curves, commercial tests, and operation of direct current generators and motors. Required of all Electrical Engineering students, first semester, Junior year. (4 units)

102. Elementary Alternating Currents.—Elementary study of alternating currents by analytical and graphical methods. Measuring instruments; inductance and capacity, harmonic electromotive force and harmonic current; problems of reactive circuits; reasonance; problems of coils in series and multiple; the application of complex quantity; single and polyphase alternators; single and polyphase systems; synchronous motor, and simple rotary converter. Numerous problems are worked Text: Elements of Electrical Engineering, Franklin and Esty, Vol II. Required of all Electrical Engineering students, second semester, Junior year. (9 units)

103. Electrical Engineering Laboratory.—Continuation of course 101 and to supplement course 102. Practical operation of direct current generators, three-wire and multiple systems; measurement of alternating current power; analysis of characteristics and determinations of efficiency, regulation, rating, and other tests on alternating current apparatus. Photometric measurements. Required of all Electrical Engineering students, second semester, Junior year. (6 units)

104. Alternating Current Analysis.—A brief review of the principles of harmonic electromotive forces and currents as given in course 102, followed by a thorough study of complex quantities and vector analysis, as applied to the static transformer; principles and theory of the transformer; the induction motor; the transmission line. This course will be supplemented as far as possible by lectures given by men engaged in commercial and engineering work, and by visits to the various electrical plants in the vicinity. Required of all Electrical Engineering students, first semester, Senior year. (10 units)

105. Electrical Engineering Laboratory.—A course in electrical testing. Required of all electrical engineering students both semesters, senior year. (6 units each semester)

106. Electrical Engineering.—Materials used in transmission line and machine construction; wave form analysis; electric railways and storage batteries; general features of telephone and telegraph engineering. Required of all electrical engineering students, second semester, senior year. (10 units)

107. Electrical Engineering Laboratory.—A combined course of testing for design characteristics of electrical machines, and a study of electrical design, with complete drawings and data for some standard piece of electrical apparatus. Required of all Electrical Engineering students, second semester, senior year. (3 units)

108. Electrical Communication.—A study of the elements of telephone, telegraph, and call systems. Prescriptive, first semester, senior year. (5 units)

109. Illumination and Distribution.—A study of illumination for street, dwellings, and public buildings, followed by a study of approved methods and materials for the distribution of electrical energy in cities, towns, and factories. Prescriptive, second semester, senior year. (5 units)

140. Direct Current Machinery.—Abridged course in direct currents, but otherwise similar to course 100. Required of Mechanical Engineering students, first semester, junior year. (5 units)

141. Electrical Laboratory.—To supplement course 140. Operation and commercial tests of direct current machinery. Required of all Mechanical Engineering students, second semester, junior year. (3 units)

142. Alternating Current Machinery.—A study of the fundamental principles of alternating current machinery. Required of all Mechanical Engineering students, second semester, junior year. (6 units)

143. Electrical Laboratory.—To supplement course 142. Operation and commercial tests of alternating current machinery. Required of all Mechanical Engineering students, first semester, senior year. (3 units)

144. Industrial Electricity.—The application of electrical apparatus for industrial purposes. Required of all Mechanical Engineering students, first semester, senior year. (5 units)

ELECTRICAL ENGINEERING EQUIPMENT

The apparatus for electrical laboratories has been so installed as to permit the arrangement of the laboratories into a miniature system of power

distribution if desired. Nearly all the machines used for testing purposes are of one rating, that is, the motors are 10 horse-power and the generators have a capacity of 7½ kilowatts, these being more satisfactory than the smaller sizes because they show the same characteristics as those used in commercial work, and because they may always be selected from standard stock. Moreover, the pieces of apparatus are so selected with regard to voltage and speed that nearly all of the motors and generators may be grouped into pairs, each pair being capable of operation as a motor generator set.

Power Apparatus.—One three-unit Allis-Chalmers motor generator set consisting of a 75 horse-power, 50 cycle, 2200 volt induction motor, with auto-starter, directly connected to and mounted on the same bed plate with two 25 kilowatt, 125 volt, direct-current generators; one three-panel white marble switchboard for building distribution, equipped with knife switches, cartridge fuses, and watt hour meters only; one six-panel natural black slate (General Electric Company) switchboard, two panels of which have plug terminals by means of which the leads running from one set of testing machines may be connected to those running to any other similar set; two of the other four panels are used to control the direct current generators of the three unit set, and are equipped with field control, ammeters, voltmeter, circuit breakers, switches, etc.; one of the remaining panels has on it three alternating-current ammeters, a three-phase circuit breaker, a three-pole knife switch, and serves to supply three-phase, 110 volt, alternating-current, to the laboratories; the remaining panel is equipped with graphic ammeter, a starting switch, and an oil switch, with overload release, and serves to control the 75 horse-power motor-generator set; two 7.5 kilowatt compound Westinghouse direct-current generators, usable also as motors; one 10 horse-

power, four-pole series Westinghouse motor, usable also as a generator; one Westinghouse 7.5 kilowatt rotary converter with connections for 1, 2, 3, and 6-phases and usable as a regular or inverted rotary converter, double-current generator, synchonous or direct current-motor, and a 3-wire direct-current generator; two inter-pole, variable speed, 10 horse-power, General Electric motors; one 10 horse-power, squirrel cage type, General Electric, three-phase, induction motor, with starting compensator; one 7.5 kilowatt, revolving field, Central Laboratory Supply Company generator, with connections for 1, 2, 3, and 6 phases, and usable also as a synchronous motor; one 3 horse-power, three-phase, Westinghouse induction motor; one 1.5 kilowatt single-phase Central Laboratory Supply Company generator, usable also as a synchronous motor; one 1.5 kilowatt Crocker Wheeler dynamotor; one 0.5 kilowatt Edison bipolar generator; one 0.25 horse-power Lundell motor; one General Electric voltage regulator, Tirrill patent; one 5 kilowatt, cruciform core, General Electrical transformer; two 600-watt General Electric transformers; two 3000-watt auto-transformers; two potential transformers; two specially wound transformers with connections for two-to-three-phase transformation; Leeds and Northrup station photometer, with Lummer-Brodhun screen, motor driven lamp rotor, and other fittings; standard lamps certified by Bureau of Standards; alternating and direct-current arc lamps; miscellaneous switches; circuit breakers; lamp boards; models; wiring supplies, tables, etc.

Measuring Instruments.—Standard Model 5 Weston voltmeter; standard milli-voltmeter with shunts for determining current values; milli-ammeter; a collection of portable ammeters and voltmeters for both alternating and direct current work, the collection being so chosen as to include instruments of the plunger, D'Arsonval, inclined coil, electro dynamometer, hot wire, and electrostatic types,—the trade names for some of the types being the American, Hartman & Brown, Keystone, Thompson, Weston, and Whitney; three Weston indicating wattmeters;

one Westinghouse 1, 2, and 3 phase indicating wattmeter; Stanley, Westinghouse, and other watt-hour meters; one Westinghouse power-factor meter; one General Electric synchronism indicator; one General Electric frequency meter, and also one Hartmann & Braun vibrating reed frequency meter.

MECHANICAL ENGINEERING

The arrangement of studies and methods of treatment in class-room and laboratory are so planned as to ground the student thoroughly in principles. Emphasis is laid upon fundamental theory; but at the same time practical experiments, vital problems, and carefully directed observations are utilized to give a firm grasp upon theory and to render it immediately useful. In all his work, the aim is to give the student an insight into both the theoretical analysis and the practical treatment of engineering problems. Particular emphasis is laid upon the application of correct methods under concrete conditions. By the study of conspicuous illustrations of mechanical processes in accessible engineering establishments and technical publications, the student becomes conversant with the trend of current engineering practice. Text-book and lecture courses are given in Mechanism, Theoretical and Applied Mechanics, Strength of Materials, Hydraulics, Construction Details and Machine Design, Graphic Statics and Structural Design, Hydraulic Motors, Steam Engineering and Power-Plant Engineering. The laboratory courses comprise work in the Materials Laboratory, Hydraulics Laboratory, Mechanical Laboratory, and Steam Power-Plant Laboratory.

150. Mechanism.—Kinematics of machines, various examples of mechanism in machinery, geometry of motion of parts, velocity diagrams, various linkages, cam motions, toothed gearing, belt and chain drive, and the mechanism of machine tools. In the latter part of the course are considered ball bearings, complex mechanical movements, link motions and valve gears for steam en-

gines. Required of Mechanical and Electrical Engineering students, both semesters, sophomore year. (4 units each semester)

151. Machine Design.—A critical study of the problems involved and the best methods of solution employed in designing various machines; the choice of material; the arrangement of members to insure accessibility; balancing of parts; distribution of material and design of bearing surfaces to insure greater durability at minimum cost. Required of Mechanical Engineering students, first semester, junior year. (6 units)

152. Machine and Engineering Construction Details.—Concrete examples of machine design are taken, as lathes, planers, blowers, pumps, hydraulic presses, boilers and steam engines. Examples from current engineering practice are discussed. Many machines and structures are studied in detail. Required of Mechanical Engineering students, second semester, junior year. (6 units)

160. Theoretical and Applied Mechanics.—Statics, dynamics, work and energy, impact and friction. Required of all Engineering students, first semester, junior year. (10 units)

161. Graphic Statics and Structural Design.—The graphic study of forces in machine and structural members, with special reference to the design of steel and reinforced concrete structures. Beams, plate girders, roof trusses and bridges of various forms are designed and analyzed. Required of all Engineering students, second semester, junior year. (5 units)

162. Strength of Materials.—A course in mechanics of materials; a study of the fundamental relations between stress and deformation in elastic materials; a consideration of the flexture of beams and of the strength of columns, plates, springs, foundations, arches, retaining walls, etc. Required of all Engineering students, second semester, junior year. (5 units)

170. Steam Engineering.—A study of thermodynamics, simple and compound steam engines, functions of steam engine valve gears and governors, steam turbines, and auxiliary governing apparatus. Required of Mechanical and Electrical Engineering students, first semester, senior year. (5 units)

171. Power Plant Engineering.—An investigation of the problems connected with the design, installation and operation of steam plants; a study of the design and operation of boilers, steam engines, steam turbines, condensers, gas and gasoline engines, fuels, chimneys, mechanical draft and various auxiliary apparatus. Many problems concerning power plant economy and the conversion of mechanical into electrical energy will be studied in detail, especial emphasis being laid upon those features peculiar to plants recently constructed according to the most advanced and approved methods. Required of Mechanical Engineering students, second semester, senior year. (9 units)

180. Mechanical Laboratory.—Strength of Materials.—Investigation of the properties of cement and concrete, tensile, compressive and bending tests of various materials used in engineering structure, tests of endurance, torsional resistance, fragility and hardness of metals. Required of all Engineering students, first semester, junior year. (6 units)

182. Mechanical Laboratory.—Tests of lubricants, investigation of friction, calibration of engineering instruments as gauges, indicators, etc., fuel analysis and calorimetry, brakes and dynamometers, steam calorimeters, injector tests, indicator and indicator cards, planimeters, various tests on steam engines relative to valve setting, governor adjustments, developed horse-power, steam consumption and efficiency of operation. Required of Mechanical Engineering students, first semester, senior year. (8 units)

183. **Mechanical Laboratory—Abridged Course.**—Similar to subject **182,** but abridged for needs of electrical engineering course. Required of Electrical Engineering students, first semester, senior year. (4 units)

184. **Steam and Power Plant Laboratory.**—Steam engine tests, gasoline engine tests, steam pump tests, boiler tests, steam turbine tests, heating plant tests, operation and tests of complete steam plant including accessories, visits and reports on various large power plants of Southern California, special investigation in mechanical engineering lines in connection with thesis work. Required of Mechanical and Electrical Engineering students, second semester, senior year. (8 units)

MECHANICAL ENGINEERING EQUIPMENT

The equipment in the various laboratories was selected with great care and with a view to performing such tests and experiments as are valuable in assisting the student to gain a thorough understanding of the theory of design, as well as a practical knowledge of the laws of operation of the machines and apparatus with which he will come in contact in his engineering career.

Materials Laboratory.—The equipment of this laboratory comprises apparatus for investigations relative to the strength, endurance, elasticity and hardness of cement, steel, wrought iron and various other materials of construction. The present facilities include a 30,000-pound Riehlé universal testing machine, with extensometers, compressometers and other accessories; a 50,000-inch-pound Olsen torsion testing machine; a Landgraf-Turner alternating impact machine; a 1000-pound cement testing machine, briquette moulds, sand and cement sieves, Gilmore and Vicat needles, Candelot's specific gravity apparatus, Le Chalelier's specific gravity apparatus, hydrometers, thermometers, and apparatus for the determina-

tion of porosity, absorption and other properties of materials. The laboratory motive power consists of a 1 h. p. Westinghouse motor for individual drive and a 5 h. p. variable speed friction driving device mounted on a truck and adapted to operate the various machines of this laboratory.

Mechanical and Steam Laboratories.—A Williams improved Westphal balance, Carpenter's viscosimeter, Doolittle torsion viscosimeter, hydrometers, specific gravity apparatus, together with flash, burning and chill apparatus are provided for the testing of lubricants. A 1200-pound Riehlé oil testing machine is employed for the investigation of friction and the other properties of lubricants. A Parr standard calorimeter for solid and liquid fuels and a Sargent gas calorimeter are employed in analyzing fuels and in determining their theoretical heating value. An assortment of steam gauges, a barrel calorimeter, separating calorimeter and throttling calorimeter furnish facilities for the study of the properties of steam. Complete tests are made on a 25 h. p. Atlas steam engine, provided with a fly wheel governor, a throttling governor, a Prony brake, an Austin steam separator, a Sargent steam meter and a Thompson indicator. The equipment also comprises the following apparatus: A 5 h. p. Fairbanks-Morse gasoline engine, a small steam pump, a Lunkenheimer injector, a Pemberthy automatic injector, a Hancock double tube injector, an Alden transmission dynamometer, a Kenerson's transmission dynamometer, a Schuchardt and Schütte portable tachometer and a planimeter.

Laboratory Shop Room.—A small shop room is employed in connection with the laboratory practice. The equipment comprises a 14-inch Lodge and Shipley engine lathe, a 20-inch drill press, a sensitive drill, emery wheels, vises, and a large assortment of the usual machine shop tools. A 5 h. p. Fairbanks-Morse motor furnishes the motive power.

CIVIL ENGINEERING

The course in Civil Engineering, while possessing much in common with the other branches, has more to do with civic relations and developments.

Intercommunication by electric and steam railways, highways, and canals; systems of water supply, irrigation, and drainage; the location, surveying, and mapping of large and small tracts of land; the construction of bridges, tunnels, arches, and other structures of steel, concrete, and masonry, in which principles relating to the strength of materials and the stresses and strains produced by various forces are considered—all of these subjects form part of the ever-enlarging province of Civil Engineering.

The instruction in this course is given by means of lectures, recitations, and work in the field, laboratory, and draughting room. The climate of Pasadena is adapted to field practice every week of the year. Lectures by civil engineers in active practice help to keep the student in touch with professional work. A compact but complete hydraulics laboratory is a part of the equipment.

200. Surveying.—Instruments used in surveying; adjustment and care of instruments; proper methods of keeping field notes; chaining, precautions to insure accuracy; leveling; making profiles and contours; the transit and its use for horizontal and vertical angles and running lines; measuring, subdividing, and mapping land in the country and city; stadia surveying; drafting room methods. Required both semesters, sophomore year. (12 units each semester)

201. Highway Engineering.—Design, construction, and repair of country and city roads and pavements; methods

of grading; comparison of different types of construction for different kinds of traffic; contracts and specifications for construction. Required first semester, junior year (3 units)

202. Railway Surveying.—Theory of railway location and survey; simple and compound curves; transition curves, switch work, and setting slope stakes for excavation and embankment; drawing of profiles and plans, and estimation of cost. Searle's Field Engineering and Crandall's Transition Curve and Earthwork will be used, with weekly practice in the field with level or transit. Required first semester, junior year. (9 units)

203. Theory of Structures.—This course is devoted to the study and design of structures in wood, steel, masonry and concrete. Stresses and strains are tested by analytic and graphic methods, and problems are given in the proportioning of parts. Required both semesters, junior year. (10 units first semester, 12 the second)

204. Sewerage and Drainage Systems.—The collection, treatment, and disposal of sewage, the draining of land; the construction of septic tanks for cities; the construction of filtration works and the method of cleaning filters; arrangement and construction of diversion weirs, regulators and speciai works. Required first semester, junior year. (5 units)

206. Water Supply and Hydraulics.—This is a course dealing with applications of the principles of mechanics to water supply and distribution for domestic purposes, irrigation, or power. The student spends part of the time in the field or laboratory with current meters, pressure gauges or other instruments for determining velocity, discharge, and loss of head; and part of the time working such problems as might occur in practice. The principles governing the action of centrifugal and other pumps are taught, and computations are made for various lifts and discharges of water with various types and sizes of pumps. Required first semester, senior year. (12 units)

207. Reinforced Concrete and Other Arches.—The arched rib of steel, masonry, and concrete; arched ribs with ends fixed and jointed; old and new theories of the arch, with applications of modern methods; permissible working pressures; analytic and graphic treatment with assistance of the integraph. Required first semester, senior year. (6 units)

208. Bridge Design.—Various types of railway and highway bridges; pin-connected and riveted bridges; single and multiple systems of bracing; moving, dead and wind loads; design of details; application of influence lines for different loadings; work in the draughting room in design; estimates of cost of erection. Required both semesters, senior year. (8 units first semester 9 the second)

209. Railway Economics.—Location and maintenance of way; train resistance, relation of curves and grades to maximum trainload; construction of railway yards, trestles and culverts; block signalling and interlocking methods; ballast, track, and accessories. Required second semester, senior year. (3 units)

210. Engineering Specifications.—Standard specifications; methods of inspection; engineering contracts; preparation of drawings for contractors and workmen; general instructions and precautions. Required second semester, senior year. (4 units)

211. Astronomy and Geodesy.—The system of coordinates for representing the positions of the heavenly bodies; applications of spherical trigonometry; use of the Ephemeris and star catalogues; theory of the instruments used and their errors and adjustments; latitude and time by solar observations; observations of the fixed stars; mean time and sidereal clocks and chronometers; observations and computations and reductions for time, error of clock or chronometer. Required second semester, senior year. (9 units)

212. Advanced Surveying.—Meridians and base lines; astronomical methods for determination of position; systems of triangulation, primary, secondary and tertiary; adjustments of results of observations; computation of geodetic positions; connecting minor surveys with triangulation systems. Required second semester, senior year. (3 units)

230. Hydraulics.—Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; hydrodynamics. Required of all students, second semester, junior year. (5 units)

231. Hydraulics Laboratory.—Measurement of the flow of water in open channels, over weirs, through various orifices and nozzles, in pipes and conduits; experimental determination of the various loss-of-head coefficients, calibration of meters; tests of turbines, water motors, etc. Required of all engineering students, second semester, junior year. (6 units)

232. Hydraulic Motors.—Water wheels, turbines, hydraulic rams, pumps, hydraulic power transmission, special machinery, hydraulic governors, and auxiliary apparatus. Required of engineering students, first semester, senior year. (5 units)

249. Surveying Instruments.—A short course teaching the use of compass, transit, and level. Required of all mechanical and electrical engineering students, first semester, senior year. (5 units)

CIVIL ENGINEERING EQUIPMENT

For work in civil engineering the Institute owns an equipment which serves to supply the student with a broad base of both experimental and theoretical knowledge.

Surveying.—Four transits, one equipped with attach-

ments for astronomical observations, two levels, sextant, plane table and equipment, integraph, chains, poles, pins, etc.

Hydraulics Laboratory.—The hydraulics laboratory has an elaborate and flexible installation of pumps, tanks, piping, channels, gauges, meters and auxiliary apparatus adapted to the various tests relative to hydraulic theory and practice. A No. 6 Gould's centrifugal pump and a 5x10 Fairbanks-Morse duplex power-pump are connected to an 800-gallon roof tank, a 600-gallon pressure tank and a 400-gallon nozzle tank by a system of pipes and valves, in such a way that water in various volumes and at various pressures is obtainable for a large number of experiments. An 8-inch Venturi meter, four sets of Fairbanks-Morse platform scales and a 6000-gallon cement measuring tank are used for measuring the water under various conditions. This 6000-gallon measuring tank, a 15,000-gallon cement storage tank, with a 50-foot cement channel and a system of underground pipes, are built into the building structure. An assortment of nozzles and weirs, a hydraulic ram, impulse wheels, and other forms of turbines are also included in the equipment.

PHYSICS

The courses in Physics have been arranged with especial regard to the needs and interests of engineering students, but they may also be taken advantageously by students who are pursuing general courses or who expect to specialize in Physics. An attempt is made to base the work as largely as possible upon the every-day experiences of the student, and to develop in him the ability to interpret the phenomena and solve the scientific and technical problems with which he may come in contact. The chief function of the laboratory work is to give a more complete understanding of physical principles and quantities than is possible by mere lecture-room or text-book exercises. The use of instruments of precision is taught when the need for them arises in experiments which illustrate or verify some principle.

250. Mechanics, Molecular Physics, and Heat.—This course emphasizes the important principles of energy and motion and the application of these principles to familiar phenomena and simple machines. The topics covered comprise kinematics; simple harmonic motion with especial reference to the later consideration of wave motion; the general properties of matter and such special properties (particularly of liquids and gases) as correlate with the later work and give the student the idea of the essential unity of the subject. Heat is considered qualitatively as well as quantitatively, and the theory is connected with the measurements of temperature and heat quantities as made in the laboratory. Required of all engineering students, first semester, sophomore year. (8 units)

251. Physical Laboratory—Mechanics, Molecular Physics, and Heat.—Includes experiments dealing with ac-

celeration, the laws of forces and moments, hydrostatics, capillarity, laws of gases, thermometry, and expansion. Required of all engineering students, first semester sophomore year. (4 units)

252. Sound, Light, Electricity, and Magnetism.—This course, based upon and forming a continuation of Course 250, begins with a careful study of wave motion. The consideration given to sound includes its sources and transmission and the application of fundamental principles to the musical scale and musical instruments. Light treated as a wave motion, applies the laws of reflection, refraction, and interference already studied. The nature and laws of electricity and magnetism and the phenomena of electric currents, including induced currents, are carefully considered. Required of all engineering students, second semester, sophomore year. (8 units)

253. Physical Laboratory—Sound, Light, Electricity and Magnetism.—Includes experiments on the focal length of lenses, indices of refraction, elementary spectrum analysis, theory of optical instruments, and the elementary principles of electricity and magnetism. Required of all engineering students, second semester, sophomore year. (4 units)

254. Electricity and Magnetism.—A more advanced and detailed treatment of these subjects than is given in Course 252. Required of all electrical and mechanical engineering students, first semester, junior year. (3 units)

255. Electrical Measurements and Methods.—A course dealing with the theory of various electrical measuring instruments and methods, with especial reference to convenience of use, precision, and possible sources of error. Required of electrical engineering students, first semester, junior year. (2 units)

256. Electrical Measurements.—A laboratory course supplementing Course 255. Required of electrical engineering students, first semester, junior year. (2 units)

PHYSICS EQUIPMENT

William Gaertner & Company of Chicago have furnished much of the general laboratory apparatus, and the Leeds & Northrup Company of Philadelphia nearly all of the electrical measuring apparatus.

Becker, Staudinger and other balances; micrometer and vernier calipers, aneroid and mercurial barometers, spherometer, polar planimeter, measuring microscopes with micrometers, reading telescopes, optical lever, linear and angular acceleration apparatus, inertia apparatus, Kater and co-incident pendulums, ballistic pendulum, metronome, force table with Tisley harmonograph and other attachments, Young's modulus apparatus, torsion apparatus, torsion pendulum, jolly balance (Kohl), centrifugal table, harmonic motion apparatus, Boyle's law apparatus, air thermometer, mercury cistern, hydrometers, Mohr's balance, Bunsen's ice and other calorimeters, Alluard dew point hygrometer, anemometer, electrically driven turning forks, Nörenberg polariscope (Kohl), optical bench (Kohl), dial, decade and other Wheatstone bridges and resistance boxes, ballistic and other galvanometers, condensers, quadrant electrometer, standards of self and mutual inductance, electro-dynamometers, Leeds & Northrup potentiometer, standard resistances for use with potentiometer, Weston and Carhart standard cells, Kelvin composite balance, electrostatic voltmeters (Kelvin & James White).

CHEMISTRY

The course in Chemistry is planned with especial reference to the needs of engineering students, the object being to give them a training that will add to their general culture as well as to their technical equipment. To this end work in general chemistry and qualitative analysis is required of all Freshmen in the Engineering courses. In the Sophomore year there is opportunity for some exercise in quantitative analysis, especially designed for those contemplating a course in Mining Engineering.

300. General Chemistry and Qualitative Analysis.—This includes lectures on general inorganic chemistry, fully illustrated with experiments and supplemented by study of a text-book and by laboratory work. Special attention is given to class discussion and to the solution of problems. The laboratory work consists of experiments in qualitative analysis, in which emphasis is placed on careful manipulation, accurate recording of results and logical interpretation of phenomena. Text: Alexander Smith's General Chemistry for Colleges and Morgan's Qualitative Analysis. Required of all engineering students, first semester, freshman year. (12 units)

301. General Chemistry and Qualitative Analysis.—This includes lectures and recitations as in the foregoing course, taking up metals, etc., and laboratory work in qualitative analysis. Text: Same as in Course 300. Required of all engineering students, second semester, freshman year. (12 units)

303. Quantitative Analysis.—This includes typical determination of metals and non-metals, with class-room discussions of processes and reactions, special attention being given to stoichiometry. Both gravimetric and volumetric processes are given, the aim of the course being to lay a good foundation for subsequent work in analysis as well as to give that thorough drill in careful

manipulation which is so important to the student of science in general. Text: Talbot's Quantitative Analysis. Prescriptive, first semester, sophomore year. (9 units)

304. Quantitative Analysis.—A continuation of the work begun in 303. Prescriptive, second semester, sophomore year. (9 units)

CHEMISTRY EQUIPMENT

The laboratory of chemistry is furnished with convenient work-benches, each of which is fitted with water, gas, and down-draft hoods, and contains lockers for the individual use of students. The laboratory is also furnished with a cement topped table for blast lamps supplied with gas and compressed air; also a special hood for hydrogen sulphide, which is supplied by an automatic generator. A balance room and a supply room are adjacent to the laboratory. A small private laboratory is fitted with work tables, sink, hood, etc., for the use of the instructor. The lecture room is furnished with a demonstration table fitted with water, gas, electricity, and down draft. Adjacent to the lecture room is a preparation and supply room containing apparatus and supplies for the lecture table. This department is supplied with the usual stock of chemicals, glassware, and porcelain, as well as a large number of pieces of special apparatus for demonstration purposes and for the use of students. Among the more important may be mentioned a projection apparatus, spectroscopes, projection prism, lecture table balance, analytical balances, lecture table galvanometer, electric heating and drying appliances, crystal models and wall charts. In addition to these the department is well supplied with platinum ware, quartz dishes and crucibles, and graduated glassware for use in quantitative analysis. For the use of instructors there is special apparatus for gas, water, and milk analysis, assaying and research work. This includes boiling-point and freezing-point apparatus, assay furnace, crushing and grinding apparatus, assay balance. Zeiss-Abbé refractometer, Schmidt and Haensch polariscope, Babcock milk tester, and Elliott's apparatus for gas analysis.

MATHEMATICS

The work of the engineer is so largely mathematical in character that too much emphasis can hardly be placed upon the necessity of a good foundation in mathematics. Students are advised to elect additional courses if possible.

350. Plane Trigonometry.—A course especially adapted to students of engineering, so arranged as to prepare for the practical work of computation and for the applications to the more advanced courses in mathematics, physics, etc. Prescriptive, first semester, freshman year. (6 units)

351. Computations.—This course is designed to give practice and to promote accuracy in the solution of problems. Attention is given to percentage errors and the checking of results. Short methods of computing, by means of the slide rule, tables, etc., are used whenever practicable. Required of all engineering students, first semester, freshman year. (4 units)

352. Advanced Algebra.—The course includes determinants, inequalities, irrational and complex numbers, with graphical representation of the latter, limits and indeterminate forms, convergency and divergency of series; indeterminate coefficients, with applications to integral functions, partial fractions, expansion of functions, and summation of series; theory of equations, including the plotting of entire functions of one letter, Descartes' rule of signs, the solution of higher numerical equations, derived functions, etc. Required of all engineering students, first semester, freshman year. (4 units)

353. Analytic Geometry.—A course in Plane and Solid Analytic Geometry, devoted chiefly to a study of the straight line and the conics, with a few curves of especial interest in engineering, such as the cycloid and catenary. The course in Solid Analytic Geometry is chiefly given to a brief discussion of the straight line, plane, and quadratic

surfaces. Required of all engineering students, second semester, freshman year. (9 units)

354. Differential and Integral Calculus.—The aim of this course is to familiarize the student with the processes and methods that are continually applied in the various branches of engineering. Required of all engineering students, both semesters, sophomore year. (8 units each semester)

355. Differential Equations.—A course especially designed to be helpful in the problems of physics, mechanics, and electrical engineering. Prescriptive, first semester, junior year. (6 units)

356. Spherical Trigonometry.—This course is arranged to meet the needs of students of civil engineering. In all extended surveys in which the curvature of the earth is considered, and for determination of latitude and longitude with the help of solar or stellar observations, a knowledge of spherical trigonometry is necessary. Required of civil engineering students, second semester, freshman year. (4 units)

357. Elementary Analysis.—A continuation of course 352, designed to present portions of advanced algebra of especial interest in engineering, including work in complex numbers, theory of equations, and an introduction to Vector Analysis. Prescriptive, second semester, freshman year. (4 units)

358. Least Squares.—Much weight is given to this course, which aims to enable the scientific worker properly to judge and improve the accuracy of his work. Numerous problems are given to illustrate the methods of adjusting observations and determining the precision measures of the results. Criteria for the rejection of doubtful observations are considered and methods of representing the results of approved observations by curves or equations are given. Required of civil engineering students, second semester, junior year. (5 units)

BIOLOGY[1]

370. General Biology.—This course is intended to convey such an understanding of the fundamental principles of biology as will be of value to the inquirer, not only in his professional duties, but in his life as a citizen and member of society. Characteristics of living material are observed, and the structure, development, and activities of certain typical organs are studied. This work is supplemented by a discussion of some of the most important biological theories, with the hope of opening to the student some of the practical problems and philosophical questions relating to life, growth, foods, heredity, evolution, environment, and disease. Prescriptive, first semester, freshman year. (10 units)

375. General Bacteriology.—A thorough course, during one semester, in General Bacteriology, for students interested in Biology and public health problems, and for others who desire to take up sanitary or industrial matters depending upon the activity of micro-organisms. The instruction consists of lectures, recitations, and extensive laboratory work, in which bacteria are considered for the most part from the standpiont of pure science, but also somewhat from the sanitary, industrial, or agricultural side. The course is not only a prerequisite for a study of Industrial Biology and for all work upon sewage disposal, water supply, and other municipal problems, but it has a value for all classes of students. Prescriptive, second semester, freshman year. (10 units)

GENERAL SCIENCE

380. History of Science.—A study of the origin and development of scientific knowledge. The more important sciences are traced from their simple beginnings down to the present, and biographical sketches of the more noted workers in the various fields are given. Prescriptive, second semester, junior year. (4 units)

[1]Not offered for the school year 1911-'12.

HISTORY; POLITICAL AND SOCIAL SCIENCE

It is now generally conceded that "the professional training of an engineer must comprise not only engineering proper, but the elements of the political and economic sciences as well, because these sciences enable him to give better service to society." The importance of this work to the citizen of the modern state is seen when we enumerate the issues that have held a prominent place in our national politics. Revision of the tariff, regulation of business corporations, and reform of our banking systems have been among the most important subjects of discussion. All these questions are almost purely economic in their nature. The money question, the labor question, the railway problem, speculation and crises, are further economic problems upon which every citizen ought to be able to form an intelligent opinion. A good training in business law and accounting is also considered a necessary part of a modern engineer's educational equipment. The courses offered in this department, therefore, aim to give the student an idea of the development of political, economic, and social institutions, and to stimulate his interest in the problems of the present, with a view to making him a more efficient worker in his chosen profession and a more valuable member of the community.

390. Development of European States.—A study of the origin and growth of the chief European nations. The work is begun by showing the student a picture of Europe as it was at the fall of the Roman Empire and another of the same field as it is today, and then, without any other

consideration to break the continuity of thought, an effort is made to show him exactly how the one evolved out of the other. Careful attention is also given to the influence of racial elements and of the various economic, religious, and political institutions on the development of social life in the different periods and countries considered. Required in all courses, first semester, junior year. (6 units)

391. **Contemporary History.**—A course emphasizing the principal features of contemporary world-politics. An examination is made of the political, social, and economic conditions of those countries under consideration, with a brief historical sketch to show the character of each country's development. Students are required to read extensively and to prepare such papers as may be suggested by the work, and approved by the instructor. Prescriptive, first semester, junior year. (5 units)

396. **Problems in American Government.**—A review of American political and social conditions from the Colonial period to the present, treating of early English progress toward union and independence, of the Federal Constitution and the growth of nationality, of the conflict with state sovereignty, of the evolution of the slavery struggle, of reconstruction, and the policy of the country regarding some of the important problems confronting the nation and the states. Required in all courses, second semester, junior year. (6 units)

397.—**Municipalities.**—A study of the origin, development, and administration of modern city government, with a comparison of the problems and administration of the principal American and European cities. Prescriptive in second semester, junior year. (5 units)

398. **The Development of the State.**—A course giving a definite exposition of the fundamental principles and organization of the state, and tracing political development from its rude beginnings in the horde-tribe to its various modern governmental expressions in the United States, England, Continental Europe, and New Zealand; indicating also the chief steps in the evolution of written con-

stitutions and the growth of liberty and democracy. Prescriptive, second semester, sophomore year. (5 units)

400. Elementary Economics.—A study of the characteristic concepts of economic thought, designed to acquaint the student with the vocabulary of the subject and the current theories of social and economic interpretation. The work includes a summary of economic history, an examination of the meaning and scope of economics, and a discussion of the production, distribution, exchange, and consumption of wealth; the wage question; labor organizations; co-operation and profit-sharing; panics and depressions, and socialism. Required in all courses, first semester, senior year. (5 units)

401. Industrial History of the United States.—A general view of the industrial evolution of the country in relation to social and political changes. Attention is given to the gradual advance in agriculture, the expansion of manufacture, the invention of machinery, the service rendered by steam, the telegraph, telephone, and electricity, and the general transformation and significance of our industrial institutions. Required in all courses, second semester, senior year. (5 units)

405. Business Law and Accounting.—A course covering the laws governing ordinary business transactions and giving the student a practical training in the use of business forms. A study is made of contracts, sales, negotiable instruments, real estate, partnerships, corporations, etc. Students are also thoroughly drilled in business arithmetic and elementary bookkeeping. Required in all courses, both semesters, senior year. (4 units each semester)

406. Elements of Sociology.—The course gives a clear and concise statement of the history and field of sociology and its scientific basis and purposes. It includes a sketch of sociological theory from the time of Plato and Aristotle, and a consideration of the development of such problems as the influence of nature and society, the idea of progress, the concepts of social unity, individualism and collectivism, etc. Prescriptive, first semester, sophomore year. (5 units)

THE ENGLISH LANGUAGE AND LITERATURE

The Institute requires an English course of four years for graduation, recognizing that language, the chief means of expression, is the most important tool in an engineering equipment. The intention in the literature courses is rather to familiarize students with the masterpieces and the general history of English literature than to attempt a close critical study. Appreciation, however vaguely felt, is believed to be preferable to criticism. The work in English is technical in courses 410, 411, and 416, and cultural in the others. Not that there is a distinct line of cleavage—the practice in writing reacts to increase the appreciation for good writing, and vice versa. The work is organic, and will, it is hoped, promote as a whole that intellectual growth in the student which is the mark of the man of education.

410. Rhetoric and Composition.—The freshman course is in English Composition, covering Narration, Description, and Exposition, with special emphasis on the last. The work is based on Canby's English Composition in Theory and Practice, Bain's Exposition, and Pearson's Principles of English Prose Composition. The practice of writing is carried forward by the study of the examples in Carpenter and Brewster's Modern English Prose, and by the writing of weekly themes. The theme is considered the essential of the freshman course. These weekly exercises are corrected not only for mistakes in spelling, punctuation, and grammatical expression, but also for the inculcation of the larger principles of clearness, directness, and force, in the setting forth of ideas. Examples of good and of bad writing are cited before the class from these papers, without, of course, the mention of the author's name; by this meth-

od the students see that the points emphasized in rhetorics are discoverable in the actual practice of freshman writing. Required in all engineering courses, both semesters, freshman year. (6 units each semester)

411. Special Composition.—A course in composition supplementary to Course 410 is required of any upper classman whose written or oral work shows that he is unable to express his ideas clearly and accurately. The course consists entirely of theme writing and consultation, and may be continued in each individual case so long as the instructor deems it necessary. (3 units each semester)

412. English Literature from Chaucer to Milton.—In this course is begun a historical review of English Literature; the greater works of the period from the beginning to Milton are examined with an aim toward the promotion of literary appreciation. Text: Long, English Literature. Required in all courses, first semester, sophomore year. (4 units)

413. Eighteenth Century Literature.—A survey of this period covers the great essayists, the great early novelists, Classical poetry from Dryden to the death of Pope, and the rise of Romanticism. Text: Long, English Literature. Required in all courses, second semester, sophomore year. (4 units)

414. The Romantic Period.—Wordsworth, Coleridge, Keats, Shelley and Byron, and the prose writers Lamb, De Quincey, Coleridge, and Hazlitt. Text: Long, English Literature. Required in all courses, first semester, junior year. (4 units)

415. American Literature.—A brief examination of poetry and prose. Text: Bronson, American Literature. Required in all courses, second semester, junior year. (4 units)

416. Technical English.—A course of composition in-

volving the writing of scientific articles, the description of machines and devices, and reports upon laboratory experiments, lectures and engineering problems, with a view to facilitating clear, correct, and concise expression in connection with technical subjects. The work is conducted by regular class exercises and frequent conferences, the actual technical work of the student so far as possible being made its basis. Required in all courses, both semesters, senior year. (3 units each semester)

FRENCH, GERMAN, AND SPANISH

Candidates for a degree must offer two years of either French or German for admission to the Freshman class, and must then pursue a study of the language offered for two more years. Spanish, however, may in certain cases be substituted in the Sophomore year and carried through the Junior year. Two years of Spanish or Latin may be offered in substitution for French or German as an entrance requirement, but in such cases three years of German or French must be taken at the Institute. Classes in Elementary German and French are therefore provided, and students completing one of these may enter the regular college work in that subject.

It may be noted upon reference to the Schedules that provision is made for advanced work in French and German in the Junior and Senior classes, making possible for such as desire it a course of four years in the Institute in addition to the two years' course required for admission.

430. Elementary French I.—This course and 431 have been arranged for those offering Spanish or Latin as an entrance language and desiring to take French as required in the Institute. Grammar and reading; practice in speaking and writing French; dictations. Great attention is paid to correct pronunciation. Books used: Fraser and Squair's French Grammar, and Bacon's Une Semaine à Paris. Prescriptive, both semesters, freshman year. (7 units each semester)

431. Elementary French II.—Continuation of grammar; special study of irregular verbs. Exercises in composition and conversation. The texts used are chosen from the more familiar modern authors. Prescriptive, both semesters, sophomore year. (7 units each semester)

433. Intermediate French.—Composition and syntax are reviewed. The spoken language is freely used in the class room, with frequent dictation. Translation at sight from representative texts receives stress. The following books are used: Fraser and Squair's French Grammar, Koren's French Composition, Victor Hugo's Les Misérables, and some French scientific reader. This course or 443 is required of engineering students offering French or German as an entrance language, both semesters, freshman year. (7 units each semester)

434. Advanced French I.—Plays by Corneille, Racine and Moliére. Reading of scientific French continued. This course or 444 is required of engineering students offering French or German as an entrance language, both semesters, sophomore year. (7 units each semester)

435. Advanced French II.—Victor Hugo and the Romantic School receive special attention in the first semester, Hugo's Notre Dame de Paris being read. The second semester is devoted to the modern drama, Hugo, Scribe, Rostand, and others being studied. Prescriptive, both semesters, junior year. (5 units each semester)

436. Advanced French III.—The work is based on Fortier's Historie de la Littérature Française. Special periods are studied more minutely, and class readings and reports on outside work are required. Prescriptive, both semesters, senior year. (5 units each semester)

440. Elementary German I.—This course and 441 have been arranged for those offering Spanish or Latin as an entrance language, and desiring to take German as required in the Institute. Vos' Essentials of German, and Bacon's Im Vaterland, are used, with written and oral exercises, and dictations. Prescriptive, both semesters, freshman year. (7 units each semester)

441. Elementary German II.—Continuation of grammar and exercises outlined in 440. Storm's Immensee, and

some simple plays are used. Prescriptive, both semesters, sophomore year. (7 units each semester)

443. Intermediate German.—Composition and syntax are taken in review; the spoken language is freely used in the class room, and translation at sight is regularly practiced. Texts: Lessing's Minna von Barnhelm, Schiller's Wilhelm Tell, Hodge's Scientific German reader. This course or 433 is required of engineering students who have offered German or French as the entrance requirement, both semesters, freshman year. (7 units each semester)

444. Advanced German I.—This course forms an introduction to the German literature of the Nineteenth Century. Novels from the works of Freitag, Sudermann, and Hauptmann, are used, being supplemented with Tumbo's Deutsche Reden, and Müller's Electrische Maschinen. This or course 434 is required of engineering students offering German or French as the entrance requirement, both semesters, sophomore year. (7 units each semester)

445. Advanced German II.—A continuation of 444, the work being based upon Keller's Bilder aus der deutschen Literatur, Rauter's allgemeine chemische Technologie, and Paskowske's Lesebuch zur Einführung in die Kenntnis Deutschlands und seines geistigen Lebens. Prescriptive, both semesters, junior year. (5 units each semester)

446. Advanced German III.—In this course the social forces in German literature receive special emphasis. The work consists mainly of lectures by the professor based upon texts to be announced from time to time. Prescriptive, both semesters, senior year. (5 units each semester)

450. Elementary Spanish I.—Grammar, reading conversation, dictations. Reading commenced as soon as the first elements of the grammar are mastered; combination of grammar and reading of modern authors kept up throughout the entire course. Texts: Hill and Ford's Spanish Grammar, Hill's Spanish Reader, and Valde's José. Prescriptive, both semesters, sophomore year, but may be substituted for Courses 434 or 444. (7 units each semester)

451. Elementary Spanish II.—Grammar reviewed, especially the irregular verbs. Course in modern Spanish literature, accompanied by work in composition and conversation based on the text read. Texts: Galdós' Marianela; Fernan Gaballero's La Gaviota, La Familia de Alvareda Echegaray's El Gran Galeota, Ó Locura ó Santidad; Valera's Pepita Jimenez, Tamayo y Baus, Un Drama Neuvo, Kroeh's Descripciones Scientificas. Prescriptive, both semesters, junior year. (5 units each semester)

DRAWING AND SHOP WORK

460. Mechanical Drawing and Descriptive Geometry.—Use of instruments; geometric constructions, mechanical projections, projections of inclined objects, intersections, developments of surfaces, isometric projections, fundamental principles of perspective, sketching, dimensioning, tracing, blue printing, conventional representation of materials. Required of engineering students, both semesters, freshman year. (6 units each semester)

461. Machine Drawing.—Assembly drawings from details; detail drawings from assemblies; detail drawings of bolts, nuts, keys, pipe fittings, valves, shaft couplings, bearings, etc. Required of engineering students, first semester, sophomore year. (3 units)

462. Machine Detail Drawings.—Drawings of details and assemblies from sketches made by student of machines, in shops and laboratories; problems pertaining to course in Mechanism, relating to cams, quick-return motions, gear teeth, valves, steam engines, etc. Required of engineering students, second semester, sophomore year. (3 units)

463. Engineering Design.—The design of certain machines, the subject varying with the professional course pursued. A drawing board study of the proportion, distribution and accessibility of parts, bearing areas; provisions for lubrication; convenience of operation, and the de-

tailing of parts for shop production. Required of electrical and mechanical engineering students, first semester, junior year. (3 or 5 units)

464. Mechanical Engineering Design.—Continuation of the work outlined in 463 on more complicated machines. Subject varies with student's special line of study. A foundation for thesis work. Required of all mechanical engineering students, first term, senior year. (3 units)

465. Elementary Machine Drawing.—This course is designed to acquaint the student with the laws of machine drawing as deduced from the principles of descriptive geometry and mechanical drawing. It consists in making simple machine drawings of nuts, bolts, valves, machine parts; studying the conventional methods of representing sections and auxiliary views; the construction of details and assemblies; the making of blue prints and tracings. Required of all students, who may be thoroughly acquainted with the principles of Mechanical Drawing and Descriptive Geometry, as a substitution for course 460 in both semesters, freshman year. (5 units each semester)

470. Descriptive Geometry.—The principles of projection as applied to the point, line, plane and surfaces of single and double curvature, with applications. As the third angle of projection is used in most of the shops where engineering work is designed, it is used chiefly in the class, though not exclusively. Prescriptive, first semester, freshman year. (7 units)

475. Freehand Drawing.—A course for the development of the personal powers involved in correct freehand drawing, such as correct seeing, selection, proportion, etc. It consists of plain and ornate lettering, rapid sketching in projection and perspective, and practice in perspective sketching from working drawings. Required of all engineering students, both semesters, freshman year. (1 unit each semester)

480. Wood Working.—Instruction in the care and use

of the ordinary woodworker's tools; training in sawing, planing, chiseling, and the commoner processes of the art; joinery, framing, fastening, glueing; staining and finishing. Wood turning, care and adjustment of the lathes, use of tools; ornamental turning. Required of all engineering students, first semester, freshman year. (4 units)

481. Forging.—Instruction in the mechanism and care of the forge, operation and handling of fire, heating, drawing, bending, upsetting, heading, welding, punching, clipping, riveting, drilling, grinding. Working of steel, hardening, tempering, refining. Structural and ornamental iron work. Required of all engineering students, second semester, freshman year. (4 units)

482. Pattern Making.—Instruction and practice in the making of patterns for iron and brass castings; the principles involved in the construction of patterns and the allowance for draft, shrinkage, etc., are given practical expression. Instruction in the use and making of core boxes, composite and ribbed patterns is given. Bench molding of students' patterns. Required of electrical and mechanical engineering students, first semester, sophomore year. (4 units)

483. Machine Shop Practice.—In bench and vise work the student takes up chipping, filing, scraping, polishing, laying out of work, etc. As a preparation for work on machines, a careful investigation of each machine is required, to familiarize the student with its construction and various motions, the office of each bolt, nut, handle, gear wheel, etc., being determined, and the general design being compared with other machines. The care of machines is considered at this point, and a systematic study is made of the needs of the machine for successful and rapid operation. Machine work is begun with a series of exercises illustrating the principal processes, as plain turning, facing, thread-cutting, inside boring and threading, turning of tapers, hand tool and chuck work of all kinds. At different stages of the course work is given

on the planer, shaper, drill-presses and milling machines. Students are expected to provide themselves with calipers and scale. Required of electrical and mechanical engineering students, second semester, sophomore year. (4 units)

SHOP LECTURES

490. Wood Working.—A study of the various materials, tools, and processes concerned in wood working; lectures on forestry, lumbering and the physical properties of various woods; causes of decay, preservation processes, protection against parasites and against fire; manufacture and operation of commercial wood working tools; selection of paints and glues. Required in connection with 480, one hour a week, first semester, freshman year. (2 units)

491. Iron Working.—Lectures and class discussions concerning the production and properties of the various iron and steel products; the manufacture of iron from the ore; various conversion processes for steel, wrought iron, malleable iron, etc.; heat treatment of steel, drop-forging, and commercial smithing. Required in connection with 481, one hour per week, second semester, freshman year. (2 units)

492. Pattern Making and Foundry Practice.—Class room discussion of shop problems; study of commercial methods, with especial reference to economical production; heavy casting; the casting of brass, bronze and other soft metals; die casting; essentials of design of machine parts for low cost of production in pattern shop and foundry. Required one hour per week, first semester, sophomore year, in connection with 482. (2 units)

493. Machine Shop Practice.—Class room study of machine tools and measuring instruments; methods of metal cutting; modern shop organization for rapid production of duplicate parts; use of high speed steel; gen-

eral consideration of practical machine shop problems. Required in connection with 483, one hour per week, second semester, sophomore year. (2 units)

SHOP EQUIPMENT

Wood Working and Pattern Making Shops.—These shops are fitted with benches provided with quick-acting vises and a full line of tools, together with lockers containing individual sets of small tools; a power jig saw, a band saw, 3-arbor circular saw, 16″ planer, 8″ jointer, sandpapering machine, wood-turning, mortiser, electric heating oven and glue pots, and an extension equipment of special tools for wood-working. The wood-turning shop contains 31 lathes of various sizes.

Forging.—This shop contains 21 down draft forges with anvils and a complete equipment of tools; two drill presses, emery grinders, shears, etc.

Machine Shop.—The equipment comprises benches and vises for hand work, 11 lathes of various sizes from 14″ to 20″ swing, 3 speed lathes, a 15-inch shaper, 24″ planer, 24″ drill press, sensitive drill, B. and S. universal milling machine, power hack saw and emery grinders, together with a full completement of drills, reamers, small tools, special tools, jigs and fixtures.

CURRENT ENGINEERING PERIODICALS

500. Current Periodicals.—Recent developments and noteworthy achievements in engineering practice are observed and discussed; the student is required to report in abstract on articles of interest appearing in the successive issues of the particular engineering publication assigned to him; and is expected to keep individual card files of such articles as promise to be of value for reference in his later professional career. Prescriptive, both semesters, junior and senior years. (2 units)

Roster of Students

Ayars, William Finlaw.....Freshman, Engineering
591 North Orange Grove Avenue
Salem, New Jersey

Brandt, Emil Carl.....Freshman, Engineering
394 Worcester Avenue
Pasadena

Briggs, Revoe Carlisle.....Sophomore, Engineering
340 Oakland Avenue
Pasadena

Brown, Cedric Earl.....Sophomore, General
822 East California Street
Pasadena

Ferguson, Benjamin.....Junior, Electrical Engineering
590 North Raymond Avenue
Pasadena

Gardiner, Everett Southworth.....Freshman, Engineering
Pasadena

Gerckens, Henry Bernhart.....Freshman, Engineering
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Los Angeles, California

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Pasadena

Gleason, Rutherford Erwin.....Freshman, General
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Pasadena

Hayes, Ben Hubbert .....Sophomore, Engineering
417 North Mentor Avenue
Pasadena

Hill, Albert Frederick .....Freshman, Engineering
735 North Fair Oaks Avenue
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Hill, Harold Curtis.....Senior, Mechanical Engineering
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Hovey, Chester Raymond.....Sophomore, Engineering
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Pasadena

Ricker, Claire William.....Freshman, Engineering
160 South El Molino Avenue
Pasadena

Thornburg, Charles Hix.....Freshman, Engineering
Sierra Madre, California

Tufts, William Herbert.....Freshman, Engineering
Sierra Madre, California

Ward, Royal Vincent.....Senior, Electrical Engineering
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326 Center Street
Glendora, California

Wells, Albert William.....Freshman, Engineering
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Pasadena

Wood, Herbert Sidney.....Junior, Electrical Engineering
San Gabriel, California

Young, Guy DeWitt .....Freshman, Engineering
591 North Orange Grove
Gardena, California

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