

VOLUME XXI

NUMBER 54

BULLETIN
OF
THROOP
POLYTECHNIC INSTITUTE
APRIL, 1912



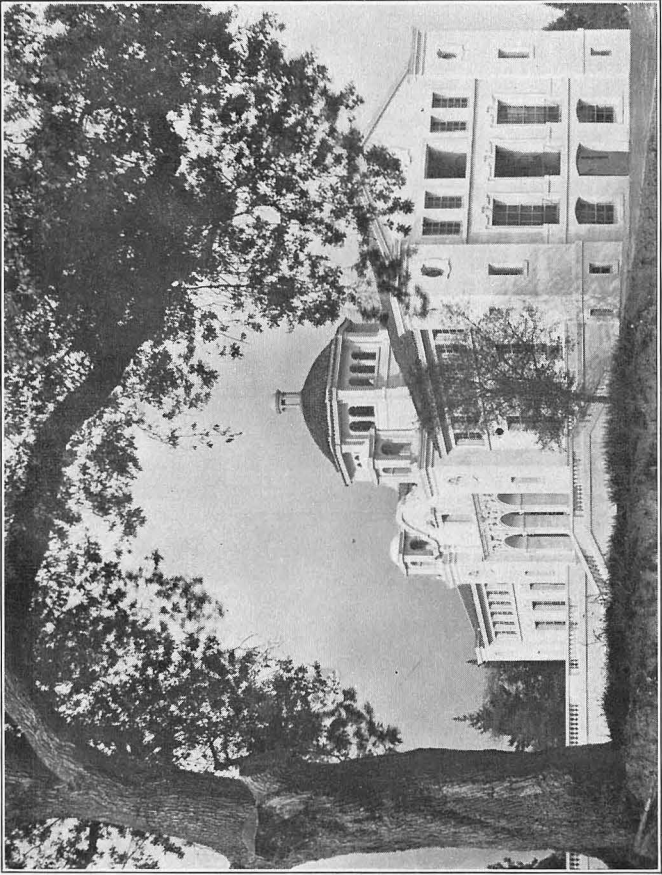
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JANUARY, APRIL, JULY AND OCTOBER

BY

THROOP POLYTECHNIC INSTITUTE
PASADENA, CALIFORNIA

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



PASADENA HALL

VOLUME XXI

NUMBER 54

BULLETIN
OF
THROOP
POLYTECHNIC INSTITUTE

A COLLEGE OF ENGINEERING
AND SCIENCE

PASADENA, CALIFORNIA

APRIL, 1912



ANNUAL CATALOGUE

FOR THE YEAR 1911-1912

INCLUDING

A STATEMENT OF REQUIREMENTS FOR
ADMISSION, A DESCRIPTION OF
THE COURSES OF INSTRUCTION,
AND ANNOUNCEMENTS

Two Presidents at Throop Institute

Theodore Roosevelt

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 today, 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."

William Howard Taft

October 16, 1911

"I am very glad to have the opportunity of wishing continued success to this institution. Vocational education is coming into practice and is justifying itself, since there is no reason why we should not start boys to learn in their youth the lessons for life instead of making them study for years without reaching any practical end and without getting to that which they intend to make their life's work. I congratulate you upon having such a splendid start and on the kind of education that you get, including technical subjects, and many of those general subjects that you will need afterward, all without taking too long a time in the preparation for professional work. You take it up here, and your mental discipline will be just as good when derived from these practical subjects as if you secured your mental discipline in the old-fashioned way but without the practical preparation for life that you are now getting."

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Calendar

1912

	S	M	T	W	T	F	S		S	M	T	W	T	F	S		S	M	T	W	T	F	S
JAN.		1	2	3	4	5	6	FEB.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	7	8	9	10	11	12	13		11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	14	15	16	17	18	19	20		18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	21	22	23	24	25	26	27		25	26	27	28	29	30	31								
	28	29	30	31																			
APRIL		1	2	3	4	5	6	MAY	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	7	8	9	10	11	12	13		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	14	15	16	17	18	19	20		19	20	21	22	23	24	25	26	27	28	29	30	31		
	21	22	23	24	25	26	27		26	27	28	29	30	31									
	28	29	30																				
JULY		1	2	3	4	5	6	AUG.					1	2	3	4	5	6	7	8	9	10	11
	7	8	9	10	11	12	13		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	14	15	16	17	18	19	20		11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	21	22	23	24	25	26	27		18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	28	29	30	31					25	26	27	28	29	30	31								
OCT.		1	2	3	4	5		NOV.						1	2	3	4	5	6	7	8	9	10
	6	7	8	9	10	11	12		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	13	14	15	16	17	18	19		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	20	21	22	23	24	25	26		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	27	28	29	30	31				24	25	26	27	28	29	30								

1913

	S	M	T	W	T	F	S		S	M	T	W	T	F	S		S	M	T	W	T	F	S
JAN.				1	2	3	4	FEB.							1	12	13	14	15	16	17	18	19
	5	6	7	8	9	10	11		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	12	13	14	15	16	17	18		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	19	20	21	22	23	24	25		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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APRIL			1	2	3	4	5	MAY					1	2	3	4	5	6	7	8	9	10	11
	6	7	8	9	10	11	12		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	13	14	15	16	17	18	19		11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	20	21	22	23	24	25	26		18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	27	28	29	30					25	26	27	28	29	30	31								
JULY			1	2	3	4	5	AUG.						1	2	3	4	5	6	7	8	9	10
	6	7	8	9	10	11	12		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	13	14	15	16	17	18	19		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	20	21	22	23	24	25	26		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	27	28	29	30	31				24	25	26	27	28	29	30								
									31														
OCT.				1	2	3	4	NOV.							1	2	3	4	5	6	7	8	9
	5	6	7	8	9	10	11		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	12	13	14	15	16	17	18		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	19	20	21	22	23	24	25		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	26	27	28	29	30	31			23	24	25	26	27	28	29	30							

Institute Calendar

1912

July 9.....	Annual Meeting of the Board of Trustees
September 10	Consideration of Applications for Admission ¹
September 18.....	Beginning of the College Year
September 18-20.....	Entrance Examinations
September 20...	Examinations for Removal of Conditions
September 21 and 23...	Registration (8 A.M. to 4:30 P.M.)
September 24..	Beginning of Regular Instruction (8 A.M.)
November 28-December 1.....	Thanksgiving Recess
December 21, 1912-January 1, 1913.....	Christmas Recess

1913

January 2.....	Resumption of Instruction (8 A.M.)
January 27-31.....	Semester Examinations
February 1.....	Examinations for Removal of Conditions
February 1.....	End of First Semester
February 3	Registration for Second Semester (8 A.M. to 4:30 P.M.)
February 4.....	Resumption of Instruction (8 A.M.)
February 22.....	Washington's Birthday (Holiday)
March 22-30.....	Spring Recess
June 2-6.....	Semester Examinations
June 7.....	Examinations for Removal of Conditions
June 8.....	Baccalaureate Sunday
June 9.....	Commencement
June 9.....	End of the College Year

¹Applications for admission, with credentials, should be mailed to the Recorder 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.

Annals of the Year 1911-1912

- September 29**—First Assembly: Invocation, the Rev. Dr. Daniel F. Fox. Address by Dr. Robert J. Burdette, on "The Little Things of Life." Greetings from the Pasadena Board of Education, by Mr. W. W. Ogier, President. Address, "The Higher Efficiency," by President Scherer. Greetings from Dean Damon, Professors Flint and Barber; and Dr. Norman Bridge, President of the Board of Trustees. Address: Dr. J. M. Rhodes, Superintendent of the Pasadena Schools.
- October 9**—Assembly Addresses by the Rev. Dana C. Bartlett and Mr. B. F. Pearson.
- October 16**—Address by President William Howard Taft: "Vocational Education."
- October 23**—Assembly Address by Mr. O. H. Ensign, Chief Electrical Engineer of the United States Reclamation Service: "Problems of the Reclamation Engineer."
- October 27**—Reception by the students and Faculty to Freshmen and new members of the Faculty.
- October 30**—Assembly Address by Mr. R. G. Goodman: "The Panama Canal."
- November 6**—Assembly Address by Professor R. W. Sorensen: "The Making of an Engineer."
- November 10**—The President's Reception to the Students.
- November 13**—Assembly Address by Mr. Russ Avery: "The California Mountains."
- November 20**—Assembly Address by Mr. G. P. Wilder: "The Commercial Side of Engineering." Remarks by Mr. George F. Kernaghan.
- November 27**—Assembly Address by Dr. Walter A. Edwards: "The True Meaning of Liberty."
- December 4**—Assembly Address by Director S. W. Stratton, Ph. D., of the United States Bureau of Standards: "The Work of the Bureau of Standards."

- December 8**—Lecture, Extension Courses, by Mr. Hamilton Holt: "The Federation of the World."
- December 11**—Assembly Address by President Scherer: "Opportunities in Southern California."
- December 18**—Assembly. Programme by the Throop Institute Branch of the American Institute of Electrical Engineers, Mr. Raymond O. Catland leading.
- January 8**—Assembly Address by the Rev. Robert Freeman: "The New Patriotism."
- January 11**—Lecture, Extension Courses, by Dr. Charles E. St. John, of the Mount Wilson Solar Observatory: "The Sun Under Investigation."
- January 15**—Assembly Address by the Rev. R. J. Campbell of the City Temple, London: "A World Without God."
- January 22**—Assembly Address by Mr. C. W. Koerner: "Central Station Management."
- January 30**—Assembly Address by M. Claude Casimir-Perier, Commissioner of the French Republic: "The War Problem of Europe."
- February 6**—Concert, Extension Courses (the Pasadena Music Hall Association), by Madame Ernestine Schumann-Heink.
- February 7**—Address and song (to students of the Institute and the Pasadena Public Schools) by Madame Ernestine Schumann-Heink.
- February 8**—Lecture, Extension Courses, by Dr. Wilfred T. Grenfell: "Labrador."
- February 12**—Assembly Address by Dr. James H. McBride: "The Student's Health."
- February 23**—Dinner of the Throop Institute Branch of the American Institute of Electrical Engineers.
- February 26**—Assembly Address by Dr. Henry Smith Carhart: "Personal Recollections."
- March 2**—Funeral of Professor Benjamin F. Stacey. Born February 7, 1869; died February 29, 1912.

- March 7**—Assembly Address by Mr. Harrington Emerson: "Efficiency." Papers by Messrs. F. Curt Miller and Benjamin Ferguson.
- March 7**—Concert, Extension Courses (the Pasadena Music Hall Association), by Harold Bauer, pianist.
- March 11**—Assembly Address by Mr. R. P. Anderson, Physical Director of the Pasadena Young Men's Christian Association: "Proper Posture." Address by Mr. E. F. Scattergood, Electrical Engineer of the Los Angeles Aqueduct: "Hydro-Electric Power Systems."
- March 18**—Assembly Address by Dean George A. Damon: "The Transportation Problem of Los Angeles."
- March 21**—Lecture, Extension Courses, by Dr. Robert J. Burdette: "Rainbow Chasers."
- March 22**—Assembly Addresses. Mr. William R. George, Founder of the George Junior Republics: "Why Boys Go Wrong." Mr. Joseph Stanley-Brown of Cold Spring Harbor, N. Y.: "The Cult of Incompetence."
- March 24**—Funeral of Professor Wallace K. Gaylord. Born November 7, 1871; died March 19, 1912.
- April 10**—Assembly address by Mr. Ralph W. Pope, Secretary of the American Institute of Electrical Engineers: "Random Reminiscences." Greetings by Mr. E. R. Northmore, Superintendent Los Angeles Gas and Electric Co.
- April 12**—Lecture, Extension Courses, by Dr. Henry S. Pritchett: "Politics as a Profession."
- April 18**—Concert, Extension Courses (the Pasadena Music Hall Association), by the Flonzaley Quartette.
- April 22**—Concert, Extension Courses (the Pasadena Music Hall Association), by Madame Emma Calvé.
- June 9**—Baccalaureate Address: Dr. Henry S. Carhart.
- June 10**—Commencement: Address by President Blaisdell of Pomona College.

These Annals are necessarily somewhat incomplete, as the Catalogue was printed early in April.

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.

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

H. H. Markham, H. W. Magee, J. C. Michener, W. U. Masters, J. S. Hodge, 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.

State of California, } ss.
County of Los Angeles, }

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, } ss.
County of Los Angeles, }

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.

(Seal)

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.....	1916
437 So. Orange Grove Ave.	
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.....	1916
South Pasadena.	
Charles W. Gates.....	1912
South Pasadena.	
James A. Culbertson.....	1916
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.	
Gen. M. H. Sherman.....	1913
Los Angeles.	

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 and Assistant Treasurer
William H. Vedder.....	Treasurer
John Wadsworth.....	Auditor
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 Henry M. Robinson James A. Culbertson

OFFICERS OF THE FACULTY

James A. B. Scherer.....	President
George A. Damon.....	Dean of Engineering
Charles Emory Barber.....	Recorder

OTHER ADMINISTRATIVE OFFICERS

Edward C. Barrett.....	Secretary, Board of Trustees 920 Delmar St.
Charles F. Holder.....	Director of the Museum 475 Bellefontaine St.
James H. McBride, M.D.....	Hygienic Adviser 489 Bellefontaine St.
M. Gladys Brownson.....	Librarian 214 South Lake Ave.
Inga Howard.....	President's Secretary 1126 Division St.

Officers of Instruction

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 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.

HENRY SMITH CARHART, A.M., LL.D.

Research Associate in Physics

A.B., Wesleyan University, 1869; A.M., 1872; LL.D., 1893.
Graduate work at Yale, Harvard, and Berlin. Professor of Physics and Chemistry, Northwestern University, 1872-1886; Professor of Physics, University of Michigan, 1886-1909; Emeritus Professor since 1909.

211 South El Molino 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.

726 South El Molino Avenue.

.....¹

Professor of Mechanical Engineering

¹Appointment to be made before September, 1912.

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.

WILLIAM RUTHVEN FLINT, M.A., Ph.D.

Professor of Inorganic and Analytical Chemistry

B.A., Yale University, 1898; M.A., 1906; Ph.D., 1909. Assistant
in Sloane Physical Laboratory, 1905-1906; Assistant in Kent
Chemical Laboratory, Yale University, 1907-1910.

129 North Hill Avenue.

RICHARD S. CURTISS, Ph. D.

Professor of Organic Chemistry and Research Associate

Ph.B., Sheffield Scientific School, 1888; Ph.D., University of
Würzburg, 1892; Graduate work at Munich and Paris.
Assistant Chemist, Connecticut Agricultural Experiment
Station, 1888-1890; Docent and Instructor, Organic Chem-
istry, University of Chicago, 1893-1897; Professor of Chem-
istry, Hobart College, 1897-1901; Union College, 1901-1904;
University of Illinois, 1904-1912.

CLINTON KELLY JUDY, B.A.

Professor of the English Language and Literature

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

32 Bowen Court.

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. In-
structor in the Romance Languages, University of Minne-
sota, 1899-1904; Instructor in French and English, Deutsche
Schule, Antwerp, 1904-1906.

1145 Chicopee Street.

HARRY CLARK VAN BUSKIRK, Ph.B.

Associate Professor of Mathematics

Ph.B., Cornell University, 1897. Graduate work at Cornell
University.

723 North Michigan Avenue.

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

Assistant Professor 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 EMORY BARBER, A.M.

Assistant Professor in History and Economics

A.B., University of Nebraska, 1904; A.M., 1905; Special student, University of Chicago; Scholar in American History, University of Nebraska, 1904-1905. Associate Professor of History, Occidental College, 1905-1907.

1311 North Catalina Avenue.

HERBERT BOARDMAN PERKINS, S.B.

Associate in Civil Engineering and Mathematics¹

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.

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

Associate in Mechanics and Machine Shop Practice

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.

53 Stevenson Avenue.

¹The John Wadsworth Chair.

W. HOWARD CLAPP, E.M.

Instructor in Machine Design and Mechanics

E.M., University of Minnesota, 1901. Instructor in Mathematics, Macalester College, 1907-1908; Superintendent and Designing Engineer, Sherman Engineering Company, Salt Lake City, 1905-1909; Superintendent, Nevada-Goldfield Reduction Company, Goldfield, Nevada, 1909-1910.

95 South Mentor Avenue.

CHARLES ANDREW BRAUTLECHT, PH. B.

Instructor in Chemistry and Physics

Ph.B., Sheffield Scientific School, 1906; Research work in chemistry with the Connecticut Agricultural Experiment Station, 1906-1909; Graduate work with Yale University.

WALTER WILLIAM MARTIN¹

Instructor in Wood Working

Normal Arts Department, Throop Polytechnic Institute, 1900.

973 Locust Street.

CLARENCE ARTHUR QUINN¹

Instructor in Forging

Normal Department, Stout Institute, 1897.

818 North Catalina Avenue.

¹Associated with the Pasadena Polytechnic High School.

Introductory¹

THE VALUE OF TECHNICAL TRAINING

Mr. Thomas A. Edison recently discussed the importance of technical education in a manner at once so informal and so convincing that his words may well serve as a fitting introduction to this catalogue. In an interview last December Mr. Edison said:

There is no question that the country today needs technically educated men.

There is no question that our nearest approach to real, sensible, usable education lies in the technical school.

I don't believe that our ordinary colleges are wrong; that they do not have their place in our life and education. But I do think that the technical schools have a more important place. And I will tell you why:

In the first place, there is no disputing the fact that the ordinary colleges turn out excellently equipped professional men. The usual classical education is of great benefit to the man who wants to be a lawyer, or, for example, who wants to pursue a literary career. But we have too many lawyers in America, too many professional men, too many men who are trying to pursue a literary career.

And we do not have enough men whose training has been such as to enable them to cope with the actual conditions of life. We do not have enough men who understand, from A to Z, the science of business. Most of all, we have not enough engineers. In industry and in business we need more men with engineer's training.

We need them as engineers. Simply as engineers and skilled workmen in our various industries, we have not enough technically educated men. We have not enough skilled "laborers" in industry. We need engineers who

¹For Historical Sketch, see page 106.

thoroughly know engineering, both its theory and its practice.

We need them—these men with engineers' training—as business men. The man who is to go into the office end of a great industrial concern ought to know all the ins and outs of the business, as well as the man who goes into the draughting room. The man in the office, the man who steps by reason of money or inheritance into a high place in the firm, ought to know the details of his industry, so that he will not be fooled by his foremen or managed by his managers. If his business is to succeed for himself and turn out the best possible products for the community, it is well that he should himself have had a technical education, even if it has been found advisable for him to go to Princeton or Harvard to finish up with a classical year or two afterward.

And we need technically educated men here in America to help us in the problems of industry and "big business." There is no use of our expecting "a bunch of lawyers" to make laws and hand down decisions with regard to industry. They can't do it. They don't know industry; they don't know business. They are ignorant of the inter-relations of trade and of manufacture. We have no right to expect a group of lawyers to solve our industrial problems and clear away our industrial clouds. It is simply impossible for them to do it. Special training is necessary in order to grapple with industry—special technical training. And that is not the sort of training that these men have had.

What is more, we need technically educated men in this country because—I, for one, am firmly convinced—technical education is a good thing for a man's character and his citizenship. We cannot put the value of citizenship altogether on a basis of education, of course; the question of morals enters into that too closely.

But I feel most strongly that technical training is a sort of training that is good for a man's character, and that enhances his value to the community and State.

A boy who goes to the "Boston Tech" has to work.

He has to think. And he has to keep on working and thinking all the time or else he will go down. The technical school does raise the standard of character and citizenship—and I am not sure that the ordinary college does. The technical school is altogether a more serious proposition.

When people are busy of their own accord they are usually found to be good citizens. The "tech" graduate is usually found to be busy of his own accord.

To return to the need for technical training. America needs chemists, engineers, all sorts of technically educated men, because this is a new country with industries to open up and develop, and because it is a commercial country with big business to manage in the right way.

And there is such a demand for those trained men! We haven't nearly enough of them. The other day a man came to me and asked me to suggest two men for \$10,000 positions. I couldn't do it. I wanted a man myself to fill a \$10,000 position, and I couldn't find him. There were plenty of threes, but no tens. And there are places waiting for the men whose education is such as to fit them to earn \$10,000 a year. Our "higher" schools ought to teach young men the things that they are going to need, to use, every day.

Germany is doing that. And Germany is getting the trade of the world. Germany not only has excellent technical schools and plenty of them, but she sends her young men to England and other places and sets them to work in shops, coming up from the bottom to learn the trade.

There is of course a movement throughout America in favor of more technical training. But the movement is going too slowly. The institutions for teaching Latin are growing faster than the institutions for teaching the problems of life. The institutions to teach boys what they ought to know are not growing fast enough.

A technical education means, after all, just one thing. A technical education means that a man knows his environment. He understands the conditions under which

his ordinary life must be lived. He understands the relations of force to matter. He has learned much of relations in the conditions of life, and he can cope with those conditions. A good technical school turns a man out ready to meet life, while the ordinary college sets him adrift in a world of which he knows nothing.¹

THE GROWTH OF THE INSTITUTE

In discussing the new educational policies of Throop Polytechnic Institute (in February, 1908), Dr. George E. Hale, of the Board of Trustees, spoke as follows:

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,

¹The Technology Review.

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 constituents of a separate institution known as Throop Academy, which was afterwards merged with the new Polytechnic High School supported by the City of

Pasadena. The Institute began the first year in its new quarters with only thirty students left in its classes, being resolved to live up to its standards.

Meanwhile, with large 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 grove of oaks and orange trees, near the southeastern boundaries of the city, and flanked by the mountains, as the campus for 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 power plant, with steam and hydraulics laboratories, was occupied with the opening of the new institution in September, 1910. 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. During the year 1911 the Endowment was enriched by gifts from four friends in the sum of \$250,000, and all debts were cancelled.

TECHNICAL OPPORTUNITIES IN SOUTHERN CALIFORNIA

Throop Polytechnic Institute is a college of applied sciences, with the essential humanities. Its chief aim is to produce skilled and resourceful engineers who are also broadly cultured. It is the only institute of technology west of the Mississippi River. That its own immediate environment offers

unusual opportunities for technically trained men may be gathered from the following excerpts from a report recently made by an official of the United States government:

The utilization of electrical power has, indeed, attained a wonderful development in Southern California. The electrical energy is generated in hydraulic and steam plants by alternators and transmitted at high tension. . . . There are numerous indications of the rapid industrial and manufacturing development on the coast in general, and this brings with it many technical problems. The most important industries are the oil and fruit industries, in both of which California takes a front rank. The oil industry brings with it the problems of the accurate measurements and testing of oil, much of which is transmitted directly to the large purchasers by pipe lines. The question of fuel value is also receiving consideration, and judging from the tendency to specify fuel value in coal contracts, it is highly probable that a similar practice will be adopted for oil purchased for fuel purposes. The discovery of the oil fields has been followed by the establishment of refineries, the largest being the El Segundo plant of the Standard Oil Company, near Los Angeles. The California oils are, in general, very rich in asphaltum, used so extensively in paving, road making, water-proofing, etc. In preparation for the completion of the Panama Canal, extensive harbor improvements are being made. The coast is also considerably interested in the comparative value of tufa concrete, tufa being added to the cement to cheapen the construction, and in the deterioration of concrete by crude oil in connection with the problem of oil storage. The testing of structural materials is obviously of the utmost importance in a locality having the phenomenal growth shown by Southern California.

The Institute's courses are so planned as to provide for training in all of the above-mentioned subjects, as it seeks to relate itself closely to the in-

dustrial problems of its environment. Its aims were tersely expressed in the concluding words of Dr. Henry Smith Carhart's address at the dedication of "Pasadena Hall:"

I have seen young men develop into engineers who are now engaged in leading work in the world. They are directing large operations in telephone companies, holding influential posts in electric light and power industries, directing new enterprises destined to develop resources, superintending manufactories of large moment, and supervising construction undertaken by the reclamation service of the federal government. Such men as these give me great hope for the future of this institution also, planted in the most attractive spot of the empire of California south of the Tehachepi. This is a region abounding in undeveloped possibilities. Its water powers, its mines, its reservoirs of liquid fuel, its irrigation possibilities, coupled with a soil in which Nature has been lavish in her gifts of productiveness, and its ocean shore in touch with the wealth of the Orient, all combine to offer a field to the aspiring engineer unsurpassed in history and written all over with fetching inducements to noblest effort.

The young man who wishes to become a component part of this empire as an engineer will enter this Institute and take a straight course through, looking for no short cuts to a degree, expecting no magician to lift him over hard work, and later to put him down softly in easy engineering positions. To such the Throop Institute says, "Come this way!"

ENVIRONMENT

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. Pasadena 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 40, affords a unique and successful example of co-operation between a school and a municipality for mutual benefit, and for the assistance of young men in self support.

The Olive Cleveland Loan Fund is described on page 40. The Institute does not give free tuition, but does what is better. Out of this Fund, devised especially and solely for the purpose, it may lend to worthy young men (without interest) the amount of their tuition, to be repaid after they acquire an income of their own.

Expenses are listed on page 44.

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 courses may be secured either through certificate from an approved school or the College Entrance Examination Board; or by examinations conducted by the Institute. Forms will be furnished on request. 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.

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 of the Institute.

The College Entrance Examination Board may be addressed at "Post Office Sub-station 84, New York City." This Board's examinations for 1912 will be held June 17 to 22. Applications for examination should be in the hands of the Secretary of the Board by June 1, 1912.

Applicants not admitted by certificate are required to pass entrance examinations. These examinations, both for admission and for advanced standing, are held at the Institute at 8 a.m. on Wednesday, Thursday, and Friday, September 18, 19, and 20, 1912; and on Monday, February 3, 1913. Applicants who find it necessary to take such examinations should notify the Recorder 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 such an examination is taken. Entrance examinations should ordinarily not exceed two hours in length for each subject.

All Applicants must be prepared in 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 for admission to Engineering Courses is as follows:

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

¹Engineering students not offering French or German must study one or the other of these languages for three years at the Institute.

²These may include any secondary subjects, not indicated above, which meet the approval of the Faculty of the Institute.

The following grouping is strongly advised for admission to the General Courses:

English	3
Mathematics	3
Chemistry	1
Physics	1
United States History and Government.....	1
Other subjects	6
Total	15

Students having preparation that does not include the mathematics and science as above described will find themselves at a great disadvantage, particularly after the Freshman year.

Applicants presenting fewer than the required fifteen units for admission to full Freshman standing, may (for the present) be admitted conditionally to Freshman courses, provided they are not deficient in more than two units, and that both of these units be not in the same subject (modern languages alone excepted). The resulting "condition," however, must be removed by the beginning of the Sophomore year, preferably on the last day of the preceding semester.

Students admitted with deficiencies undoubtedly pursue their work at a disadvantage as compared with those admitted without conditions, and the Institute does not contemplate a continuance of the policy of conditional admission after September, 1913.

In all cases, whether a student is admitted to full standing or otherwise, his work during the Freshman year is regarded as a probation to determine more fully his seriousness of purpose and his qualifications to carry successfully the more advanced work of the Institute.

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 admission to advanced standing may be had on request, and should be returned to the Recorder 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.

To teachers and to persons of mature age engaged in technical pursuits, and wishing to devote some time to scientific study, the Institute desires to offer the amplest opportunities in its lecture rooms and laboratories. Such persons may in general be admitted without formal examination, on satisfying the Faculty that they are qualified to undertake the work proposed. They will be expected after admission to attend the same exercises and examinations as other students.

DESCRIPTION OF ADMISSION SUBJECTS

The following outlines will indicate the kind and amount of work acceptable to the Institute. Additional information regarding admission requirements may be secured from the Recorder.

English.—Preparation in English has two main objects, (1) command of clear and correct English, spoken and written; (2) ability to read with accuracy, intelligence, and appreciation. The candidate's written expression will be determined by his examination generally, and no paper, however accurate in subject matter, will be considered satisfactory if seriously defective in spelling, punctuation,

grammatical form, or other essentials of good usage. The ability to appreciate literature will be tested by an examination upon certain books which have been studied. Students preparing directly for the Institute may follow the list given below, which is grouped so as to form a four years' course. The lists of the College Entrance Examination Board, of the various college associations, or the approved list for California high schools may be substituted in whole or in part. As an aid to literary appreciation the candidate is advised to acquaint himself with the most important facts in the lives of the authors read, and with their place in literary history.

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 Ænone. (1 unit)

German.—Examinations presuppose 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, and to translate easy German prose and verse at sight, including the reading of about 150 pages of standard secondary-school German text. Examinations further presuppose the ability to translate easy prose from English into German, as well as 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 translate ordinary French into idiomatic English, and the reading of about 400 pages of secondary-school French. (4) The ability to turn easy English prose into French. (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, and the reading of about 250 pages of standard secondary-school Spanish. A correct pronunciation is insisted upon. (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 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. (2 to 3 units)

Mathematics.—Many of the difficulties commonly encountered by engineering students are due to insufficient mathematical training. Candidates for admission 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 series; 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 upon 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. ($\frac{1}{2}$ 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.

($\frac{1}{2}$ unit)

History and Government of the United States.—A knowledge of the outlines of American History, and of the nature of Federal, State, and local government. This requirement represents three things: the regular use 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 study 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, and presented at the time of the examination. (1 unit)

Chemistry.—Satisfactory preparation in chemistry can be obtained only from a full year's course including both classroom and laboratory exercises. These may be based upon any one or more of the recognized texts. Of the

time given to the subject, at least four hours a week should be expended upon individual laboratory work.

The course should present an outline of the fundamental principles of general chemistry, together with the descriptive chemistry of the commoner elements. So far as possible, emphasis should be laid both upon the relation of the science to present day life, and upon its historical and biographical aspects. This point of view is much preferred to that in which the analytical applications of the subject are considered.

The laboratory note-book should furnish a complete and systematic account of the experiments performed by the student, attention being given to three essential points: the object of the experiment, the record of facts observed and inferences drawn, and the written equation by which the reaction is represented. Note-books must be presented at the time of the examination. (1 unit)

REGISTRATION AND SCHEDULE

Registration for the first semester will take place on September 21 and 23, 1912, and for the second semester on February 3, 1913, 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 Recorder 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

Every student is required to attend all class and Assembly exercises, and to satisfy the requirements in each of his subjects in such ways 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.

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.

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 Recorder at least ten days before the first regular examination day.

No student will be exempt from assigned examinations. 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 fulfil the requirement 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.

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.

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.

Students are held responsible for any careless or willful destruction or waste of Institute property. Students whose work is unsatisfactory by reason of lack of diligence may at any time be asked to withdraw from the Institute. 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 exclusion, and that he is not permitted to represent the Institute on any public occasion. Suspension means exclusion for a definite period. Dismissal is exclusion for an indefinite 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 Institute.

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 as the general policy of the Institute:

For the conduct and character of its students a college assumes a far more intimate responsibility than a university. Toward mere thoughtlessness and exuberance 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.

Dr. James H. McBride, whose professional standing is indicated by the fact that in 1909-'10 he was president of the American Academy of Medicine, is the hygienic adviser for students, and will address them during the year on personal hygiene. He may be consulted by students at assigned hours without payment of fee.

SCHOLARSHIPS, PRIZES, AND BENEFITS

THE CLEVELAND LOAN FUND

This Fund was established by Miss Olive Cleveland, under an agreement which became effective in 1903, for the purpose of aiding students to obtain an education. The income is lent without interest to worthy students who may 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.

THE PUBLIC WORKS SCHOLARSHIPS

Mr. William Thum, of Pasadena, has established 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 of the

city of Pasadena, thereby gaining valuable experience in practical business and municipal affairs while making their own way through college.

TRAVEL SCHOLARSHIP PRIZES

A friend of the Institute, who believes in the educative value of travel, has established two scholarship awards to be known as the Junior and Freshman Scholarship Prizes, respectively.

The Junior Scholarship Prize, consisting in ample provision for a trip to Europe, is awarded on each commencement day to that member of the Junior class who has the best record in scholarship for the Sophomore and Junior years, the Faculty taking also into account, in assigning the award, considerations of deportment, or good manners, and ability for original work. No award shall be made, however, unless the Faculty shall adjudge some member of the class to be sufficiently distinguished in scholarship to justify it. This prize is \$750 cash.

The Freshman Scholarship Prize, consisting in full provision for a journey through some of the principal cities of the Eastern United States, over a route recommended by the Faculty, is awarded on each commencement day to that member of the Freshman class who has the best scholarship record for the year, good manners and the quality of initiative being also taken into account. This prize is \$250 cash. No award shall be assigned in case the Faculty deem the record insufficient to justify it. The Faculty may, in some instances, permit this prize to be used for other purposes than travel, but reserve the right to indicate the mode of its use in case of any such exception.

THE CONGER PEACE PRIZE

The Rev. Everett L. Conger, D.D., in the promotion of interest in the movement toward universal peace and for the furtherance of public speaking, has established the Conger Peace Prize. The income from one thousand dollars is given annually as a prize for the composition and delivery in public of the best essay on some subject related to the peace of the world. The general preparation for the contest is made in the English work of the second semester of the sophomore year, as described on page 91.

EXTENSION COURSES

In co-operation with the citizens of Pasadena, the Institute offers each year, at a merely nominal fee, extension courses in science, literature, and music, the scientific series being given in conjunction with the Solar Observatory of the Carnegie Institution of Washington. These courses now have the valued assistance of the Shakespeare Club and the Pasadena Music Hall Association. During the last few years the following speakers and subjects have been included in the Throop Extension Courses:

SCIENTIFIC

Theodore Roosevelt: "A Zoölogical Trip through Africa."

Director George E. Hale, of the Mt. Wilson Solar Observatory: "The Work of the Solar Observatory;" "Solar Vortices and Magnetic Fields;" "Recent Work on Mt. Wilson."

Prof. J. C. Kapteyn, of the University of Groningen: "The Distribution of the Stars in Space;" "The Trees as Weather Recorders."

Prof. Charles Frederick Holder, Director of the Throop Museum: "Charles Darwin."

President G. Stanley Hall, Clark University: "Borderland Psychology."

President David Starr Jordan, Leland Stanford, Junior, University: "The Conservation of Our Fisheries."

Dr. Frederick H. Seares, of the Mt. Wilson Solar Observatory: "Variable Stars."

Prof. William Conger Morgan, of the University of California: "The Secrets of Flame."

Dr. Walter S. Adams, of the Mt. Wilson Solar Observatory: "Some Applications of Spectrum Analysis."

Dr. Arthur S. King, of the Mt. Wilson Solar Observatory: "The Spectroscope in Modern Science."

Mr. Walter McClintock: "The Blackfeet Indians."

Mr. Ferdinand Ellerman, of the Mt. Wilson Solar Observatory: "Photography in Astrophysical Work."

Dr. Wilfred T. Grenfell: "Labrador."

Dr. Charles E. St. John, of the Mt. Wilson Solar Observatory: "The Sun under Investigation."

MUSICAL

Miss Alice Coleman: Lecture Recitals on "Beethoven and Schumann," "Chopin and Liszt," "Modern Composers," "Classic Forms in Pianoforte Composition," "Development of Modern Lyric and Dramatic Forms." Three Chamber Concerts (with the Brahms Quartette).

Madame Ernestine Schumann-Heink: Concert Recital.

Harold Bauer: Pianoforte Recital.

The Flonzaley Quartette: Concert Recital.

Madame Emma Calvé: Concert Recital.

LITERARY AND GENERAL

Dr. Ernest Carroll Moore, Yale University: "Mexico and Its Schools."

President James A. B. Scherer, Throop Polytechnic Institute: "Shakespeare as a Teacher."

Prof. Clinton K. Judy, Throop Polytechnic Institute: "Wordsworth, Coleridge, Keats, and Shelley;" "Tennyson and Browning;" "Morris, Swinburne, and the Rossettis."

Mr. Charles Zueblin: "The Twentieth Century City."

Mr. Jacob Riis: "The Making of an American."

Mr. Hamilton Holt: "The Federation of the World."

Dr. Robert J. Burdette: "Rainbow Chasers."

President Henry S. Pritchett, of the Carnegie Foundation: "Politics as a Profession."

LIBRARY AND READING ROOM FACILITIES

The tower room of Pasadena Hall was modeled after the Radcliffe Camera at Oxford University especially to accommodate the Library. This consists of a carefully selected collection of about six thousand volumes, including the Cooke Loan Collection in German and French. While the main body of the library is scientific in character, there is a generous admixture of history, philosophy, and literature. A persistent endeavor is made to keep abreast of the times, especially in the addition of bound volumes of technical and scientific periodicals. The library is treated as a tool shop, entering into the routine use of all departments as a matter of course. Every facility is afforded for its free utilization, including the use of the Dewey Decimal system and a dictionary card catalogue under direction of a trained librarian.

The reading room, which is always open, contains generous files of leading technical journals, with a careful selection of magazines of a more general interest. The class work in Current Periodicals is described on page 101.

EXPENSES

Tuition is \$150 a year, payable in two equal installments, one at the beginning of each semester. There is also a fee of \$3 a year for locker rental,

and upon graduation a diploma fee of \$10. The cost of books and supplies ranges from \$15 to \$25 per year.

No reduction or refund is made to any student who may be suspended or expelled, or who may leave the Institute without a reason that shall be deemed valid by the Faculty Council; nor is any refund allowed for attendance equaling 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. A few students have "boarded themselves," but such a plan of living is not generally recommended; some secure board and lodgings in exchange for a few hours of daily labor. Many opportunities are found for partial self-support, besides those offered by the Public Work Scholarships. (See page 40.)

Schedules of Courses

ENGINEERING

The courses offered by the Institute include Electrical, Mechanical, and Civil Engineering, all leading to the degree of Bachelor of Science. During the first two years these three courses are practically identical, as the fundamental scientific principles underlying engineering work are of the same vital importance for all branches of the profession. After two years devoted to thorough preparation in Mathematics, Drawing, Shop Work, Physics, Chemistry, English, and French or German, the student is encouraged to specialize according to his aptitude and ambition. The professional courses in the three branches of engineering necessarily diverge more or less, each laying particular emphasis on problems peculiar to itself. Yet even in these advanced courses, various engineering 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

General Courses, leading to the degree of Bachelor of Science, may be made up from the subjects listed on page 58, and described in the pages thereafter following. Students in General Courses must take all the required work of the Freshman year as shown in the following schedules; all the required work of the Sophomore year common to the Engineering courses; and all of the required English, History, and Economics of the Junior and Senior years. The remainder of their work is prescriptive, varying in accordance with their respective plans and requirements. Ordinarily some major subject is prescribed, such as Organic Chemistry, which might lead, for example, to an acquaintance with the technology of petroleum, as indicated on page 80. In every case the diploma awarded by the Institute shows the exact course taken by the student throughout his entire attendance, including the total number of weeks devoted to each subject, and the quality of academic achievement. The General Courses afford the opportunity of securing a thorough collegiate education in which science predominates, but with a generous admixture of other cultural studies, all of which are pursued according to the methods and standards of a professional school.

GRADUATION

The degree of the Institute represents not only the completion of one of its courses of study, but also the attainment of a high standard of efficiency. Any student who fails to show in his Senior year that he has attained such a standard may be re-

quired to do such additional work as shall test his ability to reach that standard, this work to take such form as the Faculty may prescribe.

For graduation, a total of 384 units is required in the Engineering Courses, and 400 units in the General Courses.

Each candidate for a degree must prepare a thesis on some subject included in his course, or an account of some investigation made by him, or an original report or design accompanied by a complete exposition. Subjects of theses are announced by the Faculty at the close of the Junior year, whenever possible, and theses must be submitted to the Faculty for approval at least a month before Commencement. All theses, and records of work done in preparation therefor, remain the property of the Institute, and may not be published except by its authority.

EXPLANATION OF TERMS

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 60.

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

The 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.

ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING FIRST YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Labora- tory	Prepa- ration	
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
Inorganic 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 ¹	430	3	0	4	7
German ¹	440	3	0	4	7
Gymnasium.....					
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
Inorganic 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 ² ...	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 ¹	430	3	0	4	7
German ¹	440	3	0	4	7
Gymnasium.....					

1—If not offered for admission, either French 430 or German 440 is required.

2—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
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
Machine 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
American Government.....	399	2	0	3	5
Special Composition.....	411	1	0	2	3
Spanish ²	450	3	0	4	7
Qualitative Analysis.....	302	1	4	3	8
Surveying ¹	200	3	6	3	12
Chemistry of Carbon Compounds.....	320	2	3	2	7
2nd Semester					
Required					
Argumentation and Public Speaking.....	418	2	0	2	4
French or German.....	434 or 444	3	0	4	7
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
Machine Detail 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
English.....	413	2	0	2	4
Comparative Government.....	398	2	0	3	5
Special Composition.....	411	1	0	2	3
Spanish ²	450	3	0	4	7
Quantitative Analysis.....	303	0	6	2	8
Surveying ¹	200	3	6	3	12
Chemistry of Carbon Compounds.....	321	2	3	2	7

¹Civil Engineering students will substitute Surveying for Mechanism 150 and Shop Work 482 and 483.

²Regular Sophomore students may substitute Spanish for French 434 or German 444.

³Students finding it necessary to take French 430 and 431, or German 440 and 441, will be required to take French 433 or German 443 in the Junior year.

ELECTRICAL ENGINEERING

THIRD YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Labora- tory	Prepa- ration	
III. JUNIOR YEAR					
1st Semester					
Required					
English.....	414	2	0	2	4
Modern Europe.....	390	3	0	3	6
Theoretical and Applied Mechanics.....	160	4	0	6	10
Electricity and Magnetism..	254	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
Direct Current 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
Contemporaneous History..	391	2	0	3	5
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					
2nd Semester					
Required					
English.....	415	2	0	2	4
Problems in American History.....	396	3	0	3	6
Strength of Materials.....	162	4	0	6	5
Hydraulics.....	230				
Hydraulics Laboratory.....	231	0	6	0	3
Mechanical Laboratory.....	181				
Elementary Alternating Currents.....	102	3	0	6	9
Direct and Alternating Current 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
Differential Equations.....	359	2	0	4	6
Municipalities.....	397	2	0	3	5
Applied Heat.....	257	1	4	2	7
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					

ELECTRICAL ENGINEERING

FOURTH YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Labora- tory	Prepara- tion	
IV. SENIOR YEAR					
1st Semester					
Required					
English.....	416	1	0	2	3
Economics.....	400	2	0	3	5
Business Law and Accounting.....	405	2	0	2	4
Alternating Current Analysis.....	104	4	0	6	10
Alternating Current.....					
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
Hydraulic Motors.....	232	2	0	3	5
Prescriptive					
French.....	436	2	0	3	5
German.....	446	2	0	3	5
Advanced Calculus.....	360	2	0	4	6
Electrical Communication ..	108	2	0	3	5
Current Periodicals.....	500	1	0	1	2
Applied Optics.....	260	1	4	2	7
Chemistry (see pages 79, 80)					
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 Engineering Laboratory.....	107	0	3	0	3
Power Plant Engineering.....	172	1	0	1	2
Steam and Power Plant Laboratory.....	185	0	3	0	3
Hydraulics Laboratory.....	233	0	3	0	3
Thesis.....		0	0	12	12
Prescriptive					
French.....	436	2	0	3	5
German.....	446	2	0	3	5
Advanced Calculus.....	360	2	0	4	6
Illumination and Distribution.....	109	2	0	3	5
Engineering Specifications ..	210	2	0	2	4
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					

MECHANICAL ENGINEERING

THIRD YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Labora- tory	Prepa- ration	
III. JUNIOR YEAR					
1st Semester					
Required					
English.....	414	2	0	2	4
Modern Europe.....	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	3	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
Contemporaneous History..	391	2	0	3	5
Differential Equations.....	355	2	0	4	6
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					
2nd Semester					
Required					
English.....	415	2	0	2	4
Problems in American					
History.....	396	3	0	3	6
Strength of Materials.....	162	4	0	6	5
Hydraulics.....	230				5
Hydraulics Laboratory.....	231	0	6	0	3
Mechanical Laboratory.....	181				3
Alternating Current					
Machinery.....	142	2	0	4	6
Electrical Laboratory.....	141	0	3	0	3
Machine and Engineering					
Construction Details.....	152	3	0	3	6
Graphic Statics and Struc- tural 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
Applied Heat.....	257	1	4	2	7
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					

MECHANICAL ENGINEERING

FOURTH YEAR

SUBJECT	Subject Number	Hours per Week			Units
		Class	Labora- tory	Prepara- tion	
IV. SENIOR YEAR					
1st Semester					
Required					
English.....	416	1	0	2	3
Economics.....	400	2	0	3	5
Business Law and Accounting	405	2	0	2	4
Steam Engineering.....	170	2	0	3	5
Applied 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 Engineering 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	3	5
Advanced Calculus.....	360	2	0	4	6
Applied Optics.....	260	1	4	2	7
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					
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
Steam and Power Plant Lab- oratory.....	184	0	5	0	5
Hydraulics Laboratory.....	233	0	3	0	3
Thesis.....		0	0	12	12
Prescriptive					
French.....	436	2	0	3	5
German.....	446	2	0	3	5
Advanced Calculus.....	360	2	0	4	6
Engineering Specifications...	210	2	0	2	4
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					

CIVIL ENGINEERING

THIRD YEAR

SUBJECT	Subject Number	Hours per Week			Units
		Class	Labora- tory	Prepa- ration	
III. JUNIOR YEAR					
1st Semester					
Required					
English.....	414	2	0	2	4
Modern Europe.....	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.....	203	5	0	5	10
Sewerage and Drainage Systems.....	204	2	0	3	5
Prescriptive					
French.....	435	2	0	3	5
German.....	445	2	0	3	5
Spanish.....	451	2	0	3	5
Differential Equations.....	355	2	0	4	6
Contemporaneous History...	391	2	0	3	5
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					
2nd Semester					
Required					
English.....	415	2	0	2	4
Problems in American History.....	396	3	0	3	6
Strength of Materials.....	162	4	0	6	5
Hydraulics.....	230				
Hydraulics Laboratory.....	231	0	6	0	3
Mechanical Laboratory.....	181				
Graphic Statics and Struct- ural Design.....	161	0	5	0	5
Least Squares.....	358	2	0	3	5
Theory of Structures.....	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
Differential Equations.....	359	2	0	4	6
Applied Heat.....	257	1	4	2	7
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					

CIVIL ENGINEERING

FOURTH YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Labora- tory	Prepa- ration	
IV. SENIOR YEAR					
1st Semester					
Required					
English.....	416	1	0	2	3
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					
French.....	436	2	0	3	5
German.....	446	2	0	3	5
Advanced Calculus.....	360	2	0	4	6
Applied Optics.....	260	1	4	2	7
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					
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
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.....	446	2	0	3	5
Advanced Calculus.....	360	2	0	4	6
Current Periodicals.....	500	1	0	1	2
Chemistry (see pages 79, 80)					

Description of Subjects

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ENGINEERING

It has been the aim of the Institute so to arrange its courses as to secure a proper balance of the educational influences requisite to a successful technical career. A combination of theoretical training with practical application is brought in touch with influences that lead the student to study himself and other men, so as to develop a well rounded personality, prepared for the widest opportunities of usefulness.

All of the courses combine the following elements: the discipline resulting from the preparation of recitations from text-books; the benefits of the instructor's point of view as developed in lecture courses; the acquiring of the technic of expression and design in the drafting room; the use of instruments of precision in the laboratories; training in accuracy by the use of field instruments; the importance of system in shop tests of commercial equipment; the knowledge of physical limitations as shown by the testing of materials; and the impetus for original work as emphasized in the experimental laboratories. The student is encouraged to use the library in his reference work, and particular stress is placed upon acquaintance with contemporary engineering practice through a study of catalogues and by special courses in current technical periodicals. To develop expression and breadth of view, advanced students are required to prepare and deliver before the student body stated reviews of recent engineering developments and tendencies. Before the completion of his course

each Senior prepares a thesis representing the results of his own original thought as applied to a concrete problem.

The Institute has been peculiarly fortunate in securing the presence of eminent engineers and specialists to address the weekly assemblies, as the influence of leading personalities is an invaluable supplement to the college curriculum. The rapid development of a great industrial environment about Los Angeles affords unlimited opportunities for visits to all kinds of engineering works in process of construction, to manufacturing plants of the latest type, and to power houses of modern design, while the advancing utilization of the rich natural resources of Southern California affords many valuable examples of the methods used in drilling for oil, in making cement, in pumping, and in developing power by means of hydro-electric plants.

ELECTRICAL ENGINEERING

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 Electrical Engineering students, first semester, junior year. (8 units)

101. Direct Current Laboratory.—Uses of measuring instruments, determination of direct current machinery characteristics, efficiency tests, and the operation of direct current generators and motors. Required of 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 ca-

capacity, harmonic electromotive force and harmonic current; problems of reactive circuits; resonance; 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 Electrical Engineering students, second semester, junior year. (9 units)

103. Direct and Alternating Current Laboratory.—A continuation of direct current testing as of Course 101, and supplementary to Course 102. Efficiency tests, operation of generators in multiple and three wire systems; tests of direct and alternating current arc lamps; analysis of characteristics and determination of efficiency regulation and rating, and other tests on alternating current generators; calibration of indicating and recording meters. Required of Electrical Engineering students, second semester, junior year. (6 units)

104. Alternating Current Analysis.—A review of the principles of harmonic electromotive forces and currents, 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; single phase alternating current motors; principles of design and construction of alternating current machinery. Required of Electrical Engineering students, first semester, senior year. (10 units)

105. Alternating Current Laboratory.—Complete tests of the synchronous motor; the operation of synchronous machines in parallel; complete tests of transformers; study of polyphase connections; rotary converter tests; photometric measurements. Required of Electrical Engineering students, first semester, senior year. (6 units)

106. Electrical Engineering.—The electric railway, preliminary investigation, determination of equipment, location and design of sub-stations, use of storage batteries, comparison of alternating and direct current systems; the

transmission line, determination of economic voltage and other problems involved, line protection; elementary transient phenomena; corona; wave-form analysis. Required of Electrical Engineering students, second semester, senior year. (10 units)

107. Electrical Engineering Laboratory.—Complete tests of the induction motor; complete design of some piece of electrical apparatus, the data for which are obtained from tests made on some piece of apparatus in the laboratory for the determination of data necessary for design. Required of 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 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 Mechanical Engineering students, first semester, senior year. (3 units)

144. Applied Electricity.—This course covers the more important applications of electricity for industrial purposes, as given in courses 100, 102, 104, and 106. Required of Mechanical Engineering students, first semester, senior year. (5 units)

[See also courses 150, 160, 161, 162, 170, 172, 180, 181, 183, 185, 230, 231, 232, 233, and 249.]

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 $7\frac{1}{2}$ 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 2200 volt 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, synchronous 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 Electric transformer; two 600-watt General Electric transformers; two 3000-watt auto-transformers; two potential transformers; six 3 kilowatt transformers of special design for use in the study of polyphase connections, including 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.—A General Electric Company oscillograph, with attachments; standard Model-5 Weston voltmeter; standard Model-5 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; also milli-voltmeters with shunts for the measurements of large direct currents—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; one General Electric wattmeter for low power factor measurements; 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

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 engines. 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 min-

imum 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 flexure of beams and of the strength of columns, plates, springs, foundations, arches, retaining walls, etc. Required of all Engineering students, first half of 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, con-

densers, 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)

172. Power Plant Engineering.—A brief course, covering the design and operation of steam power plants, apparatus and auxiliaries with special reference to central station practice. Required of Electrical Engineering students, second semester, senior year. (2 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)

181. Mechanical Laboratory.—Strength of Materials Continued.—Required of all Engineering students, first half second semester, junior year. (3 units)

182. Mechanical Engineering 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 Engineering students, second semester, senior year. (5 units)

185. Steam and Power Plant Laboratory.—Similar to course 184, but abridged for the needs of students in Electrical Engineering. Required of Electrical Engineering students, second semester, senior year. (3 units)

[See also courses 140, 141, 142, 143, 144, 230, 231, 232, 233, 249.]

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 the various metals and the materials of construction. The present facilities include a 30,000-pound Riehle universal testing machine, fitted for tension, compression, and bending tests; a 50,000-inch-pound Olson torsion testing machine, a Landgraf-Turner alternating impact testing machine, a White-Souther endurance machine, a Shore scleroscope for hardness tests, extensometers, compressometers, troptometer, micrometers, and small measuring instruments. A power truck provided with motor and

variable speed friction drive furnishes the power in this laboratory.

Cement Laboratory.—A separate laboratory room is provided for the testing of cement, with slate-top work tables, briquette storage tank, moist closet, sand and cement sieves, Vicat and Gilmore needles, Candlot's and LeChatelier's specific gravity apparatus, briquette moulds, small tools, apparatus for accelerated tests on cement, temperature of setting, a 1,000-pound Riehle automatic cement testing machine.

Mechanical Laboratory.—For the testing of lubricants there are provided a Carpenter's viscosimeter, Doolittle's torsion viscosimeter, and several other types, a Williams improved Westphal balance, hydrometers, specific gravity apparatus, flash and burning point apparatus, various chemical apparatus, for the detection of adulterants, an oil testing machine of the Kingsbury type, and a 1200-pound Riehle machine for the investigation of friction and wearing qualities of lubricants. A Parr standard calorimeter for solid and liquid fuels, and a Sargent gas calorimeter with provision for the determination of sulphur are employed in analyzing fuels and in determining their theoretical heating value. There is also an assortment of thermometers, stop watches, and a platinum resistance high temperature pyrometer, with indicating apparatus.

Steam and Power Laboratories.—There are provided for testing purposes a 25 horse power Atlas steam engine with automatic fly wheel governor and throttling governor, Austin steam separator, Sargent steam meter, and indicator attachments; a Fairbanks-Morse stationary type gas engine, a Kerr steam turbine direct-connected to a Fort Wayne direct current generator; several injectors of the Lunkenheimer, Pemberthy and Hancock types, a Westinghouse motor-driven air compressor, a small duplex steam pump, two motor-driven centrifugal pumps, scales and weighing tanks, a Schuchardt & Schütte tachometer, an American-Thompson indicator,

and a planimeter; a barrel calorimeter, a separator calorimeter, and a throttling calorimeter for the determination of the quality of steam, various steam gauges, and a Crosby standard gauge tester; an Alden transmission dynamometer, a Kenerson transmission dynamometer, prony brakes for all engines; and a 150 horse power Scotch marine-type boiler with complete burners and auxiliaries for oil firing. Steam from this boiler is used for heating purposes through pressure-reducing valves, but the boiler is at all times available for laboratory work with steam pressures up to 125 pounds. The whole heating system is fitted up in a manner most convenient for making tests of its efficiency, and such tests are frequently made.

Laboratory Shop Room.—A small shop room is employed in connection with the laboratory practice. The equipment comprises a 14-inch Lodge & 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 horse power Fairbanks-Morse motor furnishes the motive power.

CIVIL ENGINEERING

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 of Civil Engineering students, 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 of Civil Engineering students 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 of Civil Engineering students 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 of Civil Engineering students 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 special works. Required of Civil Engineering students 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 solving 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 of Civil Engineering students 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 integragraph. Required of Civil Engineering students 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 drafting room in design; estimates of cost of erection. Required of Civil Engineering students 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 of Civil Engineering students 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 of Civil Engineering students 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 of Civil Engineering students second semester, senior year. (9 units)

212. Advanced Surveying.—Meridians and base lines; astronomical methods for determination of position; sys-

tems of triangulation, primary, secondary and tertiary; adjustments of results of observations; computation of geodetic positions; connecting minor surveys with triangulation systems. Required of Civil Engineering students 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 Engineering students last half 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. Required of all Engineering students last half second semester, junior year. (3 units)

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

233. Hydraulics Laboratory.—Tests of water-wheels, turbines, impulse wheels, water motors; centrifugal and other pumps; the hydraulic ram and other hydraulic appliances. Required of Electrical and Mechanical Engineering students, second semester, senior year. (3 units)

249. Surveying Instruments.—A brief course teaching the use of compass, transit, and level. Required of all Mechanical and Electrical Engineering students, first semester, senior year. (5 units)

[See also courses 160, 161, 162, 180, and 181.]

CIVIL ENGINEERING EQUIPMENT

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

Surveying.—Four transits, one equipped with attachments for astronomical observations, two levels, sextant, plane-table and equipment, integrator, planimeter, prismatic compass, leveling-rods, 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. Large volumes of water are available from a 15,000-gallon storage cistern to which all water is returned; a Gould No. 6 centrifugal pump delivers a large flow of water at low pressure, while a Fairbanks-Morse duplex power pump provides water at high pressure. The flow may be measured by an eight-inch Venturi meter, four sets of scales and weighing tanks, and a graduated 6,000-gallon cement measuring cistern. Moderate pressure is maintained by means of an 800-gallon roof tank, and for heads up to 300 feet a 600-gallon steel pressure tank served by an air compressor is provided; suction heads up to 20 feet are available for turbine draft-tubes into the low level cistern; a 400-gallon steel nozzle tank with interior baffles and screens provides attachments for various nozzles, orifices, and other experimental apparatus; a cement channel 50 feet in length provides facilities for measuring the flow of water in open channels, over weirs, etc.

A Doble impulse wheel, with glass casing, especially designed for experimental investigations; a hydraulic ram, and a motor-driven two-stage centrifugal pump are now in use, while turbines of other types will be installed in the near future; pressure gauges and a 12-foot mercury column provide for pressure measurements.

Power is furnished ordinarily by a 20 horse power direct current motor, but for heavy demands the equipment of the steam laboratory is immediately available, which brings the total up 50 horse power.

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 pursuing General Courses, or those who expect to specialize in Physics. An attempt is made to base the work as firmly as possible on 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 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 in experiments which illustrate or verify some fundamental 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 acceleration, 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 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)

257. Applied Heat.—Lectures and laboratory exercises dealing with heat as related to various industrial processes, as, for example: methods of heat transfer, radiating and heat conducting properties of materials, re-

frigeration, production, regulation and measurement of high temperatures in kilns and furnaces, calorific efficiency of fuels. Prescriptive, second semester, junior year.

(7 units)

260. Applied Optics.—Lectures and laboratory exercises on optical instruments, refraction and its use in determining properties of materials, color and illumination, radiation and its use in determining high temperatures, polarization and its use in determining properties of materials, interference and its use for purposes of measurement. Prescriptive, first semester, senior year.

(7 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. The following pieces are representative of the equipment:

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, "Geryk" air pump, 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 tuning forks, Nörrenberg polariscope (Kohl), optical bench (Kohl), induction coils, 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 courses in chemistry are designed to fulfil two general requirements. First, as fundamental to a liberal scientific training, instruction in general inorganic chemistry is given to all students in their first year. Chemical theory, the descriptive chemistry of the non-metals and the metals, and their applications in the qualitative analysis of the basic elements are discussed for the purpose both of imparting useful information and of grounding in the mind of the student the essentials of the scientific method.

Second, special training is provided, in more advanced courses, for those who wish to pursue either lines of work purely chemical in their nature, or those engineering branches in which a wider chemical experience is useful. The advanced courses include analytical, organic, and industrial chemistry. The instruction in these subjects is given by means of lectures, personal consultation, and laboratory work.

Opportunities for research, under direction of the instructors, in analytical and industrial chemistry and in the technology of petroleum, are afforded by the excellent equipment of the laboratories.

The underlying purpose in all the instruction in chemical courses is the development in the student not only of the habit of accuracy together with rapidity which results in efficient work, but also of that initiative which is essential to the solution of the scientific problems of the day.

300-301. Inorganic Chemistry.—The work of these courses naturally falls into three parts: I. Theoretical

chemistry; II. Descriptive chemistry; III. Qualitative analysis. Part I comprises a discussion of principles, inductively treated, and intended as an exemplification of the scientific method. The reactions of both non-metallic and metallic elements are freely used in illustration of the laws and theories developed by means of lectures, laboratory exercises, and classroom quizzes. Part II consists of a rapid review of the characteristic reactions of the commoner elements considered in the order of the Periodic Law. About equal stress is laid upon those reactions which are important analytically and upon those which have industrial significance. Part III is devoted to the practical application of principles and facts, previously studied, in the qualitative analysis of the basic elements.

The lectures, amply illustrated by demonstration experiments, are planned to precede the laboratory exercises. Much attention is paid to the cultivation by the student of deftness of manipulation, accuracy in observation and inference, and neatness in the recording of his work.

During the second semester, each student is expected to prepare some inorganic compound, to purify and test it, and at the conclusion to deposit with the department a well-labeled sample and a brief but comprehensive outline of the methods and processes employed. This work involves a comparative study of preparative processes, investigation of the methods of testing for impurities, and some practice in their application. So far as is practicable, the student is encouraged to depend upon his own resources and efforts in the conduct of this part of the course. Text-books: Gooch and Walker, *Outlines of Inorganic Chemistry*; Gooch and Browning, *Outlines of Qualitative Chemical Analysis*. Required of all students, both semesters, freshman year. (12 units each semester)

302. Qualitative Analysis.—The course includes practice in the analysis of alloys and various metallic industrial products, the acidic analysis, and the complete qualitative analysis of both natural and artificial substances. An excellent Browning spectroscope is provided for stu-

dent use. Text-book: Gooch and Browning, *Outlines of Qualitative Chemical Analysis*. Prescriptive, first semester, sophomore year. (8 units)

303. Quantitative Analysis.—A course of laboratory practice, with instruction by occasional lectures, but chiefly by personal consultation. An outline of the subject is presented, illustrated by those quantitative processes, gravimetric and volumetric, which are typical of its subdivisions. Prescriptive, second semester, sophomore year. (8 units)

304-305. Quantitative Analysis.—Advanced course. The instruction is furnished principally by means of individual conferences. Gravimetric and volumetric processes are studied in detail, in their relation either to pure or to applied chemistry according to the predilection of the student. Opportunity for simple research may be offered to those properly qualified. Text-books: Treadwell-Hall, *Analytical Chemistry*; Olsen, *Quantitative Chemical Analysis*; Sutton, *Volumetric Analysis*. Prescriptive, junior year. (6 units each semester)

320-321. Chemistry of the Carbon Compounds.—This course is an introduction to the compounds of carbon, giving an outline of the different series. Typical methods of preparation and the characteristic reactions of the various classes of compounds are studied. Text-book: Perkin and Kipping, *Organic Chemistry*. Prescriptive, sophomore year. (7 units each semester)

330-331. Technical Quantitative Analysis.—Practice in assaying; in iron and steel analysis; in analysis of gas and oil, furnace products, water, etc. The work is varied to suit the requirements of the student. Prescriptive, junior year. (6 units each semester)

336-337. Technology of Petroleum.—The course consists of a discussion of the origin and sources of petroleum, its composition and refining, the utilization of waste and by-products, the drilling and management of wells; and practice with the standard apparatus used in

the examination and testing of both crude oil and its products. The proximity of the important oil fields and refineries of Southern California makes frequent inspection trips a valuable feature of the instruction. Text-book: Redwood, Petroleum and Its Products. Prescriptive, senior year. (10 units each semester)

CHEMISTRY EQUIPMENT

The general laboratory, providing accommodations for sixty students, is furnished with the conventional tables, each of which is supplied with water and gas, and with lockers for storing apparatus. Side-tables, carrying shelves, are conveniently located so that students may have easy access to the chemicals and reagents needed in their experiments. Opening off from this laboratory are, first, a balance-room for use by students in elementary quantitative analysis, and, second, a large supply-room, part of which is fitted as a balance-room for the first year course. The balance-rooms are amply supplied with high-grade balances.

The lecture-room, with a seating capacity of thirty-five, contains a demonstration-table fitted with gas, water, electricity, a down draught, and projection apparatus. Adjacent is a supply-room completely stocked with apparatus and reagents for lecture-table experiments.

The research laboratory is well equipped for work in analytical chemistry and in oil. In conjunction with it, each instructor is provided with a small private laboratory fitted with tables, sink, hood, etc. The equipment for research work includes analytical balances of the finest grade, platinum and quartz ware, electric and gas drying ovens, graduated glassware, apparatus for gas, water, and milk analysis, and for assaying, and a complete outfit for work in petroleum. The stock-rooms are abundantly supplied with apparatus and chemicals of the best quality.

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. Care is taken to present both underlying principles and a great variety of applications, thus connecting the mathematical courses closely with the professional studies. 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. Calculus.—The aim of this course in Differential and Integral Calculus 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)

359. Differential Equations.—This is a continuation of course 355, and treats the following subjects: linear differential equations, integration in series, equations of the second order, differential equations with more than two variables, partial differential equations, geometrical and physical applications. Prescriptive, second semester, junior year. (6 units)

360. Advanced Calculus.—A course planned to extend the knowledge gained from the previous courses in Calculus and Analytic Geometry and lay a better foundation for advanced work in mathematics and science. Prescriptive, both semesters, senior year. (6 units each semester)

BIOLOGY¹

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 standpoint 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, and thereafter. (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)

¹Not offered for the year 1912-'13.

HISTORY AND ECONOMICS

In order that the engineer may give his best service to society, his training must comprise not only distinctly professional subjects, but the elements of political and economic science as well. Questions of large public interest such as the tariff, the currency, the regulation of railways and other corporations, the conservation of natural resources, the place and compensation of labor, are all economic in their nature. They are all questions with which every citizen should be somewhat familiar, and upon which he should be able to form an intelligent opinion; many of them are closely concerned with the duties of the engineer. Some training in business law, accounting, and finance, is also a necessary part of any engineer's equipment. The courses therefore aim to give the student an idea of the development of modern political and economic institutions, and to stimulate his interest in the problems of the present with the view of making him a more efficient worker in his profession, and a more valuable member of the community.

390. Modern Europe.—A study of the political and economic development of Europe from the French Revolution to the Twentieth Century. The course is prefaced by a brief sketch of the principal influences and movements in European History from the Roman Empire to the Revolutionary period. Required of all students, first semester, junior year. (6 units)

391. Contemporaneous History.—A course dealing with the principal features of world politics. An examination is made of the political and economic situation in the chief countries of the world, with a brief study of

their development. Considerable library work is required, together with the preparation of papers upon subjects suggested by the course. Prescriptive, first semester, junior year. (5 units)

396. Problems in American History.—A study of some of the more important problems of our history, among them the American Revolution, the making of the Constitution, the political aspects of slavery, secession, and reconstruction, together with the problems of the day. Required of all students, second semester, junior year. (6 units)

397. Municipalities.—An examination of the origin, development and organization of the modern city, with a comparison of the problems of a few of the principal American and European cities. Prescriptive, second semester, junior year. (5 units)

398. Comparative Government.—This course includes an exposition of the Theory of the State, its development and organization, and a study of the constitutional systems of the United Kingdom, the chief countries of continental Europe, and the Canadian, Australian, and South African Unions. Prescriptive, second semester, sophomore year. (5 units)

399. American Government.—A study of the American constitutional system as shown in the working of the Federal, State, and local governments. Prescriptive, first semester, sophomore year. (5 units)

400. Economics.—A study of the characteristic concepts of economic thought, designed to acquaint the student with the principles of the subject and the theories of social and economic interpretation. The course 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; socialism; taxation and public finance. 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 and its relation to social and political progress. Attention is given to the effect of scientific method upon agriculture, the invention of machinery, the development of manufacturing, and the service rendered by steam and electricity in power, transportation and communication, and the transformation and significance of our industrial institutions. Required of all students, second semester, senior year. (5 units)

405. Business Law, Accounting, and Finance.—A course covering the laws governing ordinary business transactions, giving the student training in the use of business forms, and some knowledge of the organization and financing of companies and corporations. A study is made of contracts, negotiable instruments, principal and agent, business associations and the elements of corporation finance. Students also are given considerable practice in the principles of bookkeeping. Required in all courses, both semesters, senior year.

(4 units each semester)

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, 416, and 418, 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 of the simpler Biblical narratives such as those in Snyder's Selections from the Old Testament, and, further, by the writing of weekly themes. The theme is considered the essential of the freshman course. These weekly exercises are corrected not only as to 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 method 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. Prescriptive, second semester, sophomore year, and thereafter.
(4 units)

[For the required English of the sophomore year, second semester, see course 418.]

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 involving 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)

418. Argumentation and Public Speaking.—A course in the theory of argument and in the practice of speaking. The class will engage in daily discussions of current problems. Required in all courses, second semester, sophomore year. (4 units)

FRENCH, GERMAN, AND SPANISH

Candidates for a degree should 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. Required of Engineering students offering French as an entrance language, both semesters, freshman year.

(7 units each semester)

434. Advanced French I.—Plays by Corneille, Racine and Molière. Reading of scientific French continued. Required of Engineering students offering French 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 *Histoire 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 *Imensee*, 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. Required of Engineering students who have offered German as an entrance language, 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*. Required of Engineering students offering German as an entrance language, 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 Paszkowski'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.—A college course covering grammar, reading, conversation, and 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: Wagner's *Spanish Grammar*, Valdés' *José* and Galdós' *Marianela*. Prescriptive, both semesters, sophomore year, but may be substituted for Course 434 or 444. (7 units each semester)

451. Advanced Spanish.—A course in modern Spanish literature, accompanied by work in composition and conversation based on the text read. Grammar is reviewed, especially the irregular verb. Texts: Galdós' *Doña Perfecta*; Fernan Gaballero's *La Gaviota*, *La Familia de Alvereda*; Echegaray's *El Gran Galeota*, *Ó Locura ó Santidad*; Valera's *Pepita Jimenez*, *Tamayo y Baus*, *Un Drama Nuevo*; Kroeh's *Descripciones Científicas*. Prescriptive, both semesters, junior year.

(5 units each semester)

DRAWING AND ENGINEERING DESIGN

The courses in Drawing are arranged to equip the student with the technique of expression for his future professional work. The preparatory instruction includes practice to develop manual facility in the use of instruments, exercises to develop speed and accuracy in the application of the principles of descriptive geometry, and instruction in standard lettering, shading, and dimensioning. The freehand sketching of machine parts is followed by accurate pencil drawings of details and assemblies, which are then traced in ink and blue-printed ready for use in the shop. The cultivation of the imagination by the development of original designs is an important part of the student's preparation. This idea is emphasized throughout the more advanced professional courses in which the principles of representation are constantly applied.

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 ma-

terials. Required of all 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 all 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 all 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 detailing 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 semester, 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 ac-

quainted with the principles of Mechanical Drawing and Descriptive Geometry, as a substitution for course 460 in both semesters, freshman year. (3 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)

SHOP INSTRUCTION

SHOP WORK

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 Course 480, 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 Course 481, 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 in connection with Course 482, first semester, sophomore year.

(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; general consideration of practical machine shop problems. Required in connection with Course 483, 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, sand-papering machine, wood-trimmer, mortiser, electric heating oven and glue pots, and an extensive 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, Brown and Sharpe universal milling machine, power hack saw and emery grinders, together with a full complement 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 each semester)

Degrees Conferred June 6, 1911

Harold Curtis Hill, Bachelor of Science (in Mechanical Engineering).

Stanley Morton Lewis, Bachelor of Science (in Electrical and Mechanical Engineering).

Royal Vincent Ward, Bachelor of Science (in Electrical Engineering).

Roster of Students

Allen, Robert Norman.....Freshman, Civil Engineering
Hollywood, California

Andrews, Raymond Daniel.....Freshman, Electrical
Engineering
Sierra Madre, California

Ayars, William Finlay..Sophomore, Electrical Engineering
Y. M. C. A. Dormitory
Salem, New Jersey

Beek, Joseph Allan.....Freshman, General Courses
645 South Euclid Avenue
Pasadena

Bultmann, Robert Arnold William..Freshman, Electrical
Engineering
Monrovia, California

Burt, Earle Andrews..Freshman, Mechanical Engineering
1099 Summit Avenue
Pasadena

Call, Raymond Fuller.....Freshman, General Courses
1025 North Madison Avenue
Pasadena

Catland, Raymond Osgood.....Freshman, Mechanical
Engineering
870 North Fair Oaks Avenue
Santa Ana, California

Dismukes, Walton.....Freshman, Engineering
Monrovia, California

Elliott, Verne Donald..Freshman, Electrical Engineering
835 North Raymond Avenue
Pasadena

Ferguson, Benjamin.....Senior, Electrical Engineering
San Pasqual Street and Rose Avenue
South Pasadena

Ferguson, Robert Sindorf.....Freshman, Electrical
Engineering
1640 North Fair Oaks Avenue
Pasadena

Gardiner, Everett Southworth....Sophomore, Mechanical
Engineering
R. F. D. No. 1
Pasadena

Gerckens, Henry Bernhart.....Sophomore, Mechanical
Engineering
1040 West Thirty-ninth Street
Los Angeles, California

Gerhart, Ray.....Junior, Electrical Engineering
1210 East Sixtieth Street
Huntington Beach, California

Gleason, Allen Harold....Sophomore, Civil Engineering
212 South Euclid Avenue
Pasadena

Hill, Albert Frederick.....Sophomore, Mechanical
Engineering
870 North Fair Oaks Avenue
Santa Ana, California

Holmes, William Mowry.....Freshman, Electrical
Engineering
Alhambra, California

Hovey, Chester Raymond.....Junior, Mechanical
Engineering
817 Monterey Road
South Pasadena

Humphrey, Norman Egbert.....Senior, Electrical
Engineering
968 East California Street
Escondido, California

Koch, Louis Jacob, Jr.....Junior, Mechanical Engineering
308 North Soto Street
Los Angeles, California

Langer, Louis Ernest Frank.....Freshman, Civil
Engineering
1123 Windsor Place, South Pasadena
Redondo Beach, California

Merrifield, John Dodge.....Senior, Electrical Engineering
144 West Green Street
Lindsay, California

Miller, Frank Curt.....Senior, Electrical Engineering
1116 North Marengo Avenue
Tempe, Arizona

Morse, Virgil Franklin.....Sophomore, Electrical
Engineering
300 South Hill Avenue
Pasadena

Newton, Walter Lamb.....Sophomore, Electrical
Engineering
480 Prescott Street
Denver, Colorado

Nicholls, Fred Edward.....Freshman, Mechanical
Engineering
1523 West Twenty-seventh Street
Los Angeles, California

Parkinson, Ralph Willard, Junior, Electrical Engineering
394 North Orange Grove Avenue
Colorado Springs, Colorado

Powell, Eyre.....Freshman, General Courses
370 Lincoln Avenue
Pasadena

Ricker, Claire.....Sophomore, Electrical Engineering
160 South El Molino Avenue
Pasadena

Smith, Allan Porter...Sophomore, Electrical Engineering
776 Howard Place
Pasadena

Smith, Frank Augustus.....Freshman, General Courses
Los Angeles, California

Soyster, Charles Julius.....Freshman, General Courses
102 North Holliston Avenue
Willowbrook, California

Soyster, Merwin Hammond.....Freshman, Engineering
102 North Holliston Avenue
Willowbrook, California

Wells, Albert William.....Sophomore, Electrical
Engineering
1093 Avoca Avenue
Pasadena

Wilcox, Charles Herbert.....Freshman, Mechanical
Engineering
33 Stevenson Avenue
Pasadena

Wood, Herbert Sidney.....Junior, Electrical Engineering
1611 Marengo Avenue
South Pasadena

Young, Guy DeWitt...Sophomore, Electrical Engineering
Y. M. C. A. Dormitory
Gardena, California

Roster of College Alumni

Note: Throop Polytechnic Institute was founded in the year 1891 by the Hon. Amos G. Throop, formerly of Chicago. At first it was called "Throop University;" but within a year this ambitious name was abandoned, and a title selected to set forth the clear aim of the school. "Father Throop" was an apostle of practical education. By his wise direction manual training and higher technology have become a part of the educational equipment of the flourishing Pacific coast. For many years Throop Institute was the only western source of supply for teachers of manual training in the public schools, through a department of normal arts adapted to the needs of the times. By the year 1908 the ideas fostered by the Institute had been so thoroughly embodied in the state educational system that the Board of Trustees decided to devote their whole energies to the proper aim of the school as a college of technology. Departments tending to obscure this aim, such as that of the normal arts, were relinquished, and the Institute reorganized throughout.

Following are the College alumni from the beginning:

1896

Doty, George F., A.B......Spokane, Washington
Cashier Spokane Wholesale Drug Co.

Haynes, Diantha M., A.B......Redondo Beach, California
A.B., Leland Stanford Junior University, 1905.
Instructor in Chemistry, Redondo High School.

1897

Grinnell, Joseph, A.B......Berkeley, California
A.M., Leland Stanford Junior University, 1901.
Director Museum of Vertebrate Zoology, University of California. Editor of "The Condor." Publications: Various papers on the distribution and speciation of animals, and (with Hilda Wood Grinnell) "Reptiles of Los Angeles County, California" (Throop Institute Bulletin No. 35).

1898

Blackman, Roy Beede, A.B......Dagupan, Pangasinan
Philippine Islands
Assistant Engineer, Bureau of Public Works. Pub-
lication: "Woodworking, A Manual of Elementary
Carpentry for Philippine Schools."

Jewett, Frank Baldwin, A.B......Millburn, New Jersey
Ph.D., University of Chicago, 1902.
Transmission and Protection Engineer, American
Telephone and Telegraph Company, New York
City. Publications: "Vapor Density of Sodium
Vapor," Philosophical Magazine, 1902; "Resistance
of Bismuth in a Magnetic Field," Physical Review,
1903; "The Modern Telephone Cable," American
Institute of Electrical Engineers, 1909.

1900

Harris, Irving, A.B......Mesa, Arizona
Superintendent of Construction, Salt River Project,
United States Reclamation Service.

Olson, Albert, A.B......Deceased

1901

Davidson, Leonard E., B.S......2418 Pine Street
San Francisco, California
Instructor in Manual Training, San Francisco City
Schools.

1902

Dyer, Kirk Worrell, B.S......Middletown, Connecticut
S.B., Massachusetts Institute of Technology, 1907.
Secretary-Treasurer Frisbie Motor Co.

Gaylor, James Mason, B.S....120 North Chester Avenue
Pasadena, California
S.B., Massachusetts Institute of Technology, 1907.
Engineer United States Reclamation Service.

Nicholson, Maude Louise, B.S......Pasadena, California

1903

Shoemaker, Richard Woolsey, B.S....551 South Los Angeles Street, Los Angeles, California
Electrical Engineer.

1904

Beardslee, James Louis, B.S......Deceased
McCutchan, Henry Chester, B.S.....220 East Third Street
Los Angeles, California
With Holabird-Reynolds Electric Company.

1906

Gaylord, John Clarence, B.S......1120 Meridian Avenue
South Pasadena, California
S.B., Massachusetts Institute of Technology, 1908.
Assistant Professor of Electrical Engineering, University of Southern California.
Maxson, Edgar Schuyler, B.S....Los Angeles, California¹
Test Department, Southern California Edison Co.
Norton, Frank Edward, B.S......Garfield, Utah¹
With Utah Copper Company.
Wood, Hilda, B.S. (Mrs. Joseph Grinnell)..2615 Channing
Way, Berkeley, California
Publication: (With Joseph Grinnell) "Reptiles of
Los Angeles County, California" (Throop Institute
Bulletin No. 35).

1907

Miller, James Collins, B.S....Teachers' College, Columbia
University, New York City
A.M., Columbia University, 1910.
Fellow in Education, Teachers' College, Columbia
University.
Instructor, Provincial Normal School, Alberta, Canada.

¹Latest available information.

- Pimentel, Rafael, Jr., B.S.**....4 Calle de Danceles No. 96
Mexico City, Mexico
Inspection Engineer, Development of Water Supply,
Oaxaca.
Deputy to Congress.
-

NEW FOUNDATION

1911

- Hill, Harold Curtis, B.S.**.....9 George Street
West Lynn, Massachusetts
Student-Engineer, General Electric Co.
- Lewis, Stanley Morton, B.S.**.....903 West Washington
Street, Fort Wayne, Indiana
Test Department, Ft. Wayne Electric Works.
- Ward, Royal Vincent, B.S.**.....Joliet, Illinois
Inspector, Public Service Co. of Northern Illinois.

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