VOLUME XXVI NUMBER 74

THROOP COLLEGE BULLETIN

THROOP COLLEGE OF TECHNOLOGY

CATALOGUE

EXHIBITING THE COURSES OF INSTRUCTION, THE REQUIREMENTS FOR ADMISSION, THE PLAN OF STUDY, THE COLLEGE ROSTER, AND GENERAL INFORMATION

JANUARY, 1917

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

BY

THROOP COLLEGE OF TECHNOLOGY
PASADENA, CALIFORNIA

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

VOLUME XXVI NUMBER 74

THROOP COLLEGE
BULLETIN

THROOP COLLEGE OF TECHNOLOGY

ANNUAL CATALOGUE

FOR THE YEAR 1916-1917

INCLUDING

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

PASADENA, CALIFORNIA
JANUARY, 1917

THROOP COLLEGE BULLETIN

TITLES OF IMPORTANT ISSUES

Number		
42	The President's First Annual Report.	
43	Address:	The Darwin Centennial, Charles Frederick Holder.
	Lecture:	The Distribution of the Stars in Space, J. C. Kapteyn.
51	Lecture:	A Zoölogical Trip Through Africa, Theodore Roosevelt.
57	Lecture:	Politics as a Profession, President Henry S. Pritchett.
42, 48, 53, 59, 63, 68, 71	The President's Annual Reports.	
61	Address:	Industrial Research in America, Arthur D. Little; President Scherer's Address to the Freshmen, September, 1913.
64	Paper:	Inherent Voltage Relations in Y and Delta Connections, Royal W. Sorensen and Walter L. Newton.
46, 50, 54, 58, 62, 67, 70, 74	The Annual Catalogues.	
66	Address:	"The Moral Equivalent of War," President Scherer.
68	Address:	Forestry in Relation to City Building, T. P. Lukens.
69	Addresses:	What is an Engineer?—Scientific Research in America, Dr. Arthur A. Noyes.
72	Paper:	Motor Trucks in Southern California, W. Howard Clapp.
73	Paper:	A "Home-Made" City Planning Exhibit and Its Results, Dean George A. Damon.

Copies of these Bulletins may be had, until issues are exhausted, by addressing

THE RECORDER,
THROOP COLLEGE OF TECHNOLOGY,
PASADENA, CALIFORNIA.

Contents

Calendar

1917

JANUARY

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

FEBRUARY

S	M	T	W	T	F	S
..	..	..	..	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	..	..	..
..	..	..	..	..	..	..

MARCH

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

APRIL

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

MAY

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

JUNE

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

JULY

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

AUGUST

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

SEPTEMBER

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

OCTOBER

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

NOVEMBER

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

DECEMBER

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

1918

JANUARY

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

FEBRUARY

S	M	T	W	T	F	S
..	..	..	..	..	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	..	..
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MARCH

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

APRIL

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

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

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

JULY

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

AUGUST

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

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	..	..	..	..	..
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OCTOBER

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

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

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

College Calendar

1917

JANUARY 30 ..... Registration, Second Semester
JANUARY 31 ..... Resumption of Instruction (8 A. M.)
MARCH 24-APRIL 1 ..... Spring Recess
MAY 28-JUNE 2 ..... Semester Examinations
JUNE 3 ..... Baccalaureate Sunday
JUNE 4 ..... Commencement
JUNE 4 ..... Annual Meeting Alumni Association
JUNE 4 ..... End of the College Year

AUGUST 29-31 ..... Entrance Examinations
SEPTEMBER 3 and 4 ..... Registration (9 A. M. to 5 P. M.)
SEPTEMBER 5 ..... Beginning of Instruction (8 A. M.)
NOVEMBER 29-DECEMBER 2 ..... Thanksgiving Recess
DECEMBER 16-JANUARY 1 ..... Christmas Recess

1918

JANUARY 2 ..... Resumption of Instruction (8 A. M.)
JANUARY 14-19 ..... Semester Examinations
JANUARY 19 ..... End of First Semester
JANUARY 21 ..... Registration, Second Semester
JANUARY 22 ..... Resumption of Instruction (8 A. M.)
MARCH 23-APRIL 7 ..... Spring Recess (Engineering Camp)
MAY 27-JUNE 1 ..... Semester Examinations
JUNE 2 ..... Baccalaureate Sunday
JUNE 3 ..... Commencement (10 A. M.)
Annual Meeting, Alumni Association (7 P. M.)

SPECIAL ANNOUNCEMENT

As this Catalogue goes to press, arrangements have been made for a noteworthy extension of the courses in Physics. Advanced courses will be offered next year for both undergraduate and graduate students. Instruction will be based on the plan that has been developed at the University of Chicago by Dr. Robert A. Millikan, who, by a joint arrangement with that institution, has become Director of Physical Research at Throop College. Full announcement of the new courses, as well as of new advanced courses in Chemistry, arranged by Dr. Millikan and Dr. Arthur A. Noyes, respectively, will be published in the April Bulletin, which may be obtained on application to the Recorder.

Founder

HON. AMOS. G. THROOP

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

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(Arranged in the order of seniority of service.)

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337 South Lake Avenue.
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463 North Euclid Avenue.

Officers of Instruction

JAMES A. B. SCHERER, PH.D., LL.D.

President

Lecturer in Education

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, 1905-1910; Associated with Bion J. Arnold, Consulting Engineers, Chicago and Los Angeles; Consulting Engineer, Board of Public Utilities, Los Angeles.

516 South Catalina Avenue.

ARTHUR AMOS NOYES, PHD., LL.D., SC.D.[1]

Director of Chemical Research

S.B., Massachusetts Institute of Technology, 1886; S.M., 1887; Ph.D., Leipsic, 1890; LL.D., University of Maine, 1908; Clark University, 1909; Sc. D., Harvard University, 1909; Yale University, 1913. Instructor, Assistant, and Associate Professor of Chemistry, Massachusetts Institute of Technology, 1890-1899; Professor of Theoretical Chemistry, 1899——, and Director of Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, 1903——; Acting President, Massachusetts Institute of Technology, 1907-1909.

617 South Hudson Avenue.

ROBERT ANDREWS MILLIKAN, PH.D., SC.D.[2]

Director of Physical Research

A.B., Oberlin College, 1891, A.M., 1893; Ph.D., Columbia University, 1895; Universities of Berlin and Göttingen, 1895-1896; Sc.D., Oberlin College, 1911, Northwestern University, 1913, University of Pennsylvania, 1915. Tutor in Physics, Oberlin College, 1891-1893, Assistant, 1896, Associate, 1897; Instructor, 1899, Assistant Professor, 1901, Associate Professor, 1907-1910, and Professor of Physics, 1910—, University of Chicago.

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[1]By co-operative arrangement with the Massachusetts Institute of Technology.

[2]By co-operative arrangement with the University of Chicago.

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; Consulting Engineer, Pacific Light and Power Corporation, 1913——.

726 South El Molino Avenue.

WALTER HOLBROOK ADAMS, S.B.

Professor of Mechanical Engineering

S.B., Massachusetts Institute of Technology, 1903. Assistant in the Engineering Laboratory, Massachusetts Intsitute of Technology, 1903-1905; Instructor in Mechanical Engineering, Polytechnic Institute of Brooklyn, 1905-1908; Professor of Mechanical Engineering, Imperial Pei Yang University, Tientsin, China, 1908-1912. Engineer, American Machinery and Export Company, Tientsin, China, 1912.

1661 Rose Villa Street.

FRANKLIN THOMAS, C.E.

Professor of Civil Engineering

B.E., University of Iowa, 1908; C.E., 1913. Graduate work at McGill University, Montreal. Instructor in Descriptive Geometry and Drawing, University of Michigan, 1910-1912. With E. A. Wallberg, Consulting Engineer, Montreal, 1909-1910; Designer, Alabama Power Company, Birmingham, Alabama, 1912-1913.

685 South El Molino Avenue.

LUCIEN HOWARD GILMORE, A.B.

Professor of Physics

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

649 Galena Avenue.

STUART JEFFERY BATES, PH.D.

Professor of Physical Chemistry

B.A., McMaster University, Toronto, 1907; M.A., 1909; Ph.D., University of Illinois, 1912. Chemist, Comfort Soap Works, Toronto, 1907-1908; Research Assistant, McMaster University, 1909-1910; Fellow in Chemistry, University of Illinois, 1910-1912; Research Associate in Physical Chemistry, 1912-1913. Instructor in Analytical Chemistry, University of Illinois, 1913-1914.

124 North Marengo Avenue.

CLINTON KELLY JUDY, M.A.[1]

Professor of the English Language and Literature

A.B., University of California, 1903; M.A., 1907; B.A., Oxford University, 1909; M.A., 1913.

55 North Euclid Avenue.

FREDERICK ERNEST BECKMANN, PH.D.

Professor of French, German, and Spanish

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

112 North Catalina Avenue.

HARRY CLARK VAN BUSKIRK, PH.B.

Professor of Mathematics

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

723 North Michigan Avenue.

LOUIS RICE BALL, CAPT., U. S. A., RET.; E.M., E.MET.

Professor of Military Science and Tactics

E.M. and E.Met., Colorado School of Mines, 1900; 2nd Lieutenant of Cavalry, 1899, 1st Lieutenant of Cavalry, 1901; Professor of Military Science and Tactics, University of Florida, 1906-1908; Graduate, Mounted Service School, 1909; Captain of Cavalry, 1909; Graduate, Army School of the Line, 1912, Graduate, Mounted Service School, Second Year, 1914; Retired, April 12, 1915.

292 East Bellevue Drive.

ROBERT EDGAR FORD, E.E.

Associate Professor of Mechanics and Hydraulics

B.E.E., University of Minnesota, 1895; E.E., 1900. Associated with Electric Manufacturing Co., Minneapolis, 1895; Consulting Steam and Electrical Engineer, Minneapolis, 1896-1897; Graduate work at the University of Minnesota, 1900.

137 South Madison Avenue.

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[1]Reading at Harvard University, on leave for the current school year.

SEWARD CHURCHYARD SIMONS, A.B.

Associate Professor of Economics and History

A.B., Harvard University, 1911. Advertising Manager and Organization Expert for various companies, 1912-1915; Secretary and Technical Expert Los Angeles Charter Commission, 1915; Pacific Coast Representative, J. P. Devine Company (machinery), since 1912.

1107 Buena Vista Street, South Pasadena.

W. HOWARD CLAPP, E.M.

Associate Professor of Mechanism and Machine Design

E.M., University of Minnesota, 1901. Instructor in Mathematics, Macalester College, 1897-1898. 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.

HOWARD JOHNSON LUCAS, M.A.

Associate Professor of Organic Chemistry

B.A., Ohio State University, 1907; M.A., 1908; Assistant in Organic Chemistry, Ohio State University, 1907-1909; Fellow in Chemistry, University of Chicago, 1909-1910; Chemist, Bureau of Chemistry, United States Department of Agriculture, 1910-1912. Chemist, Government of Porto Rico, 1912-1913.

127 North Mentor Avenue.

JAMES EDGAR BELL, PH.D.

Associate Professor of Chemistry

S.B., University of Chicago, 1905; Ph.D., University of Illinois, 1913. Graduate student and fellow, University of Chicago, 1908-1910; graduate student and assistant, University of Illinois, 1911-1913; Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916.

254 South Meredith Avenue.

JAMES HAWES ELLIS, PH.D.

Research Associate in Physical Chemistry

B.S. Massachusetts Institute of Technology, 1912; Ph.D., 1916. Assistant in Electrical Laboratory, Massachusetts Institute of Technology, 1913-1914; Research Associate in Physical Chemistry, Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, 1914-1916.

1139 Lura Street.

REGINALD POLE, B.A.

Assistant Professor in English

Open Musical Scholarship, King's College, Cambridge, 1907; First Winchester Reading Prizeman of the University, 1909; B.A., Cantab., 1910.

Morrison Hotel, Los Angeles.

CARL SAWYER DOWNES, PH.D.

Assistant Professor in English

A.B. Harvard University, 1907, A.M., 1908; graduate work, Oxford University, 1907-1908; Ph.D., Harvard University, 1912. Instructor in English, Leland Stanford, Jr., University, 1913-1914; Instructor in English, University of Illinois, 1914-1916.

425 Oakland Avenue.

WILLIAM ALEXANDER ENENKEL

Instructor in Modern Languages

Student, College of Philology, University of Zürich, 1908-1909; Superintendent of Modern Languages, Public Schools, City of Mexico, 1912-1913.

1211 San Pasqual Street.

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Instructor in Drawing and Mathematics

S.B., Massachusetts Institute of Technology, 1914. Architectural Designer in the office of Frank A. Bourne, Boston, 1912-1913; Assistant in Mechanical Drawing and Architectural Drawing, Massachusetts Institute of Technology, 1914-1915; Harvard Engineering Camp, 1915.

East California Street and Sierra Bonita Avenue.

WILLIAM NOBLE LACEY, PH.D.

Instructor in Inorganic and Industrial Chemistry

A.B. in Chemical Engineering, 1911, and Chemical Engineer, 1912, Leland Stanford Junior University; M.S., 1913, and Ph.D., 1915, University of California; Assistant in Chemistry, Leland Stanford Junior University, 1911-1912; Assistant in Chemistry, University of California, 1912-1915; Research Chemist for Giant Powder Co. Con., San Francisco, 1915; Research Associate, Massachusetts Institute of Technology, 1916.

1139 Lura Street.

ROBERT SINDORF FERGUSON, B.S.

Instructor in Mathematics and Electrical Engineering

B.S., Throop College of Technology, 1915.
1640 North Fair Oaks Avenue.

HENRY KITTREDGE NORTON, B.S.

Lecturer in Business Law

B.S., Dartmouth College, 1905; M.A., Pomona College, 1913. Graduate work in Education and Jurisprudence, University of California. Admitted to Bar, 1908; practicing attorney in Los Angeles, 1908——.
649 La Loma Road.

ANDREW WILLIAM SMITH, M.D.

Physical Director

M.D., University of Michigan, 1912; Medical Examiner and Physical Supervisor, City Schools, Hammond, Indiana, 1913-1914.
765 South Los Robles Avenue.

CARROLL DAVIS BILLMYER, B.S.

Instructor in Mechanical Engineering

B.S. in Mechanical Engineering, Virginia Polytechnic Institute, 1914. With Norfolk and Western Railway, Roanoke, Virginia, 1914-1916.
75 South Michigan Avenue.

ARTHUR B. MCGEE, B.S.E.

Instructor in Civil Engineering

B.S. in Engineering (Civil), University of Michigan, 1916. Assistant, University of Michigan Surveying Camp, 1916.
1487 North Los Robles Avenue.

WALTER WILLIAM MARTIN[1]

Instructor in Wood Working

Graduate, Normal Arts Department, Throop Polytechnic Institute, 1900. With Stout Planing Mills, Pomona, California, 1891-1896.
1782 Rose Villa Avenue.

CLARENCE ARTHUR QUINN[1]

Instructor in Forging

Graduate, Normal Department, Stout Institute, 1897.
818 North Catalina Avenue.

ARTHUR FREDERICK HALL[1]

Instructor in Pattern Making and Machine Shop Practice

With Sullivan Machine Company, Claremont, N. H., 1891-1894; B. F. Sturdevant Company, Jamaica Plain, Mass., 1894-1897; Union Gas Engine Company, San Francisco, 1898-1899; W. P. Kidder Machine Company, Jamaica Plain, Mass., 1899-1907.
806 West Commonwealth Avenue, Alhambra.

[1]Associated with the Pasadena High School.

Annals of 1916

January 3—Assembly Address, "Uncivic Art," by Mr. Rob Wagner, of the Manual Arts School, Los Angeles.

January 10—Assembly Address by Mr. J. D. Burks, Director of the Bureau of Efficiency of the City of Los Angeles: "Opportunities in Public Service."

January 14—Concert (Pasadena Music and Art Association), Los Angeles Symphony Orchestra, Adolf Tandler, Director.

February 2—Assembly Address by Mr. J. W. Swaren: "The Development of Water Power on the Pacific Coast."

February 4—Concert (Pasadena Music and Art Association), Los Angeles Symphony Orchestra, Adolf Tandler, Director.

February 7—Assembly Address by President Scherer: "The Pan-American Scientific Congress." Songs by the Tuskegee Singers.

February 14—Assembly Address by Dr. Hector Alliot, Curator of the Southwest Museum: "South America." Award of prizes for essays in Economics by Prof. Seward C. Simons: Fred L. Poole, '17, first prize; Clark E. Baker, '17, second prize.

February 21—Assembly Address by the Rev. Herbert E. House, of Canton: "The Real China."

February 22—Concert (Pasadena Music and Art Association), Mme. Melba, soprano; Signorina Sassoli, harpist; Mr. Frank St. Leger, pianist.

February 28—Assembly Address by Mr. Frank H. Olmstead, Consulting Engineer, Los Angeles: "Flood Control."

March 6—Assembly Address by Dr. John Bates Clark, Professor of Economics in Columbia University: "War and the Transformation of Asia."

March 13—Assembly: Songs by the Pasadena High School Glee Club; Reading by Dr. Robert Freeman.

March 20—Assembly Address by the Hon. James R. Garfield: "What this War Means to Us."

April 10—Assembly Address by Dr. Norman Bridge, President of the Board of Trustees: "The Early History of Throop."

April 17—Assembly Address by Prof. C. K. Judy: "English, Good and Bad."

April 24—Assembly Address by President Arthur Twining Hadley of Yale University: "Audax et Cautus." Unveiling of the new Seal by the Sculptor, Miss Maude Daggett.

April 27—The Conger Peace Prize Contest (prize awarded to Gene B. Heywood, '18).

May 1—Assembly, in charge of the Throop College Y. M. C. A. Address by Mr. James E. Sprunger: "Work in the Prison Camps of Europe."

May 5—Assembly Address by Mr. A. L. Rohrer: "The General Electric Company."

May 8—Assembly Address by Prof. Bruce Bliven, of the University of Southern California: "Live Hard."

May 9—Assembly Address by Captain Tenney Ross, General Staff, U. S. A.: "Military Training in Throop College."

May 15—Assembly Address by Dr. Dana Bartlett: "Facts as to Alcohol."

May 22—Assembly Address by Mr. Willis Booth: "Our Industrial Tendencies."

May 25—Lecture, Extension Courses, Prof. Frederick H. Seares, of the Mt. Wilson Solar Observatory: "The Color of the Stars."

June 2—Senior Reception for the Faculty and Students.

June 4—Baccalaureate Address, President Scherer: "America."

June 5—Commencement Day. Invocation by the Rev. John R. Atwill. Commencement Address by Mr. George S. Patton: "National Vision." Award of Travel Scholarship Prizes, Prof. Clinton K. Judy. Award of Freshman Drawing Prize, Dean George A. Damon. Conferring of Degrees, President Scherer.

June 5—Annual Banquet of the Alumni Association.

September 22—First Assembly. Introductory remarks by Captain Ball, Mr. Billmyer, Mr. Polc, Mr. Lacey, Mr. McGee, and Mr. Downes. Address by President Scherer: "Being a Freshman."

September 22—President's Reception to the Faculty and Students.

September 25—Assembly Address by Captain Louis R. Ball: "What Is a Soldier?"

October 2—Assembly Address by Dr. Albert Shiels, Superintendent of the Los Angeles Schools: "A Culture Worth Having."

October 9—Assembly Address by Mr. John W. Hart: "The Modern Judiciary."

October 10—Lecture, Extension Courses, by Sir Rabindranath Tagore, of Shantiniketan, Bolpur, Bengal, India: "The Cult of Nationalism."

October 16—Assembly. Introductory remarks by Mr. Norton, Mr. Ellis, and Mr. Bell. Political Symposium: Addresses by Jesse P. Youtz, '17, Norman I. Prosser, '18, Herbert J. Bartlett, '19, and Alexander Askenasy, '17: "The Presidential Candidates."

October 23—Assembly Report by Frank R. Capra, '19, Travel Prize Scholar.

October 30—Assembly Report by Arthur Stert, '17, Travel Prize Scholar.

November 6—Assembly Address by Mr. George M. Millard, of Chicago: "The Saints and Sinners Corner."

November 13—Assembly Address by Mr. C. Y. Knight, of the Willys-Knight Co.: "The Knight Motor." (Assembly in charge of the Throop Branch of the American Institute of Mechanical Engineers.)

November 20—Assembly Address by Dr. James H. McBride, Hygienic Adviser: "The Proper Use of Leisure."

November 27—Assembly Address by Mr. Frederick McCormick, Secretary of the Asiatic Institute, New York: "The Asiatic Problem."

December 4—Assembly Address (I) by Mr. Thomas D. Campbell.

December 7—Assembly Address by Dr. A. H. Sayce, of Oxford and Cairo: "Excavations in Egypt."

December 11—Assembly Address by Mr. Gale Seaman, College Secretary of the Y. M. C. A.: "The Influence of Great Decisions."

December 18—Student Assembly: Address (II) by Mr. Thomas D. Campbell, Carlyle H. Ridenour, '18, presiding.

December 28—Lecture, Extension Courses, by Dr. R. Tait McKenzie, Physical Director of the University of Pennsylvania: "The Physical Education of College Men."

Introductory[1]

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 Mr. Edison said:

There is no question that the country to-day 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 carcer.

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 engineers' 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 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

[1]For historical sketch, see page 130.

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.

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.

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.

THE GROWTH OF THROOP COLLEGE

In discussing the new educational policies of Throop College (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 formulæ, but is the man who, while knowing these things, has not failed to develop his breadth of view and the highest qualities of his imagination. No great creative work, whether in engineering or in art, in literature or in science, has ever been the work of a man devoid of the imaginative faculty. In seeking to develop the school, therefore, let us not forget that our prime object should be to graduate men capable of conceiving vast projects, not less than men whose abilities are limited to the power of executing them. With the rapid development of engineering in all directions, and the constant increase in the amount of detailed information placed before the student, the difficulty of securing the requisite breadth of view is serious. In most technical schools this problem has not been solved, and the opportunity stands open for Throop to devise and carry into effect a broad scheme of education which may give proper recognition to all sides of the engineer's life.

In the winter of 1908 a curriculum was devised applying these principles to the departments of Electrical, Mechanical, and Civil Engineering. In the following spring the newly elected President accompanied Mr. Hale on a visit to the leading technical schools of America and Europe, for the purpose of testing and improving this curriculum, the results being embodied in the following pages.

To complete the reorganization of the institution, 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 transferred to a new institution of their own, now in

successful operation as a polytechnic elementary school. In 1910 the College separated itself from 288 more, of a still higher grade, who became the constituents of a distinct institution known as Throop Academy, which was afterwards merged with the new Polytechnic High School supported by the City of Pasadena. This left the College free to devote its entire resources to a single clear object, the maintenance of a college of technology.

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 site 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 complete modern equipment. A second building, containing the power plant, with steam and hydraulic laboratories, was occupied with the opening of the new institution in September, 1910; a Dormitory was opened on the campus in the autumn of 1915 (see page 44); the Chemistry Building has just been completed (see page 90); and the Pasadena Music and Art Association is well advanced with plans for the erection of an Auditorium. During the last few years the Endowment has been enriched by large gifts, all debts have been canceled, and the income from a fund of $300,000 has been made available for Physical and Chemical Research, as described on pages 94 and 89, while facilities for special research in Aeronautics will soon be installed (see page 95).

ENVIRONMENT

Pasadena is not only one of the most beautiful of cities, with a climate of unexcelled equality and healthfulness, but it is also noted for the morality, refinement, and culture of its citizens. Being notably a residential town, ten miles from the factories and markets 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, of which there are few. Pasadena is known as "the city of churches and schools," and 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 social ideal of Throop College 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 College 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."

The Public Works Scholarship Fund, described on page 39, 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 39. The College 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 43.

General Information

REQUIREMENTS FOR ADMISSION

APPLICANTS FOR ADMISSION must give evidence of good moral character, and be thoroughly prepared in at least fifteen units of preparatory work; each unit representing one year's work in a given subject in an approved high school at the rate of five recitations weekly. The table of admission subjects is as follows:

English	3
Algebra	2
Plane and Solid Geometry	1½
Trigonometry	½
Physics	1
Chemistry	1
United States History and Government	1
French, German, Spanish, or Latin	2
Miscellaneous Subjects[1]	3
Total	15

Applicants who offer for entrance a total of fifteen recommended units but whose list of subjects is not in accord with this table may be admitted at the discretion of the Faculty, but students thus admitted must complete the preparation of the required subjects.

Beginning courses are offered at the College in Chemistry, Trigonometry, French, German and Spanish, but the College advises most strongly that applicants for admission be prepared in these subjects.

Candidates who do not offer French, German or Span-

[1]These may include any subjects of high school grade which meet the approval of the Faculty.

ish, for admission will be required to study one of these languages for three years at the College.

PREPARATION IN THESE SUBJECTS MAY BE EVIDENCED by the certificate of an approved school or by examination. Applicants are advised to enroll at the beginning of the academic year, as many of the subjects continue through both semesters and may not be entered in the middle of the year. Application forms will be sent upon request.

APPROVED SCHOOLS are those that maintain a full four years' course and are accredited by the various Associations of Colleges, and College Entrance Certificate Boards, or by colleges and universities of recognized standing at which the entrance requirements are equivalent to those of Throop College.

ENTRANCE EXAMINATIONS AT THE COLLEGE[1] will be given for those who prefer this method of admission, or who may desire thus to supplement incomplete certificates of recommendation. The schedule for 1917 is as follows:

Wednesday, August 29
8:00 A. M. Mathematics
2:00 P. M. English
Thursday, August 30
8:00 A. M. Physics; Chemistry
2:00 P. M. History
Friday, August 31
8:00 A. M. Foreign Languages

[1]Entrance examinations may also be taken under the direction of the College Entrance Examination Board. These examinations are held at various points in the United States on June 18 to 23, 1917. Applications for these examinations should be in the hands of the Secretary of that Board by May 28, 1917. He may be addressed at 431 West 117th Street, New York City.

APPLICATIONS FOR ADMISSION should be forwarded to the Recorder in ample time to allow for correspondence, so that candidates whose certificates are incomplete may prepare for entrance examinations in subjects not covered by their certificates.

ENTRANCE EXAMINATIONS ordinarily do not exceed two hours for each subject. Applicants taking examinations in Physics, Chemistry, or United States History must present their note books at the time of the examination.

During the Freshman year, a student's work 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 College.

APPLICANTS FOR ADMISSION TO ADVANCED STANDING coming from other institutions of collegiate rank must present letters of honorable dismissal, together with statements showing in detail the amount and character of their previous training. This work will be credited according to the standards of Throop College. In lieu of these certificates of credit, applicants for advanced standing may take examinations, for which application forms will be sent on request.

TO TEACHERS and to persons of mature age engaged in technical pursuits, and wishing to devote some time to scientific study, the College 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.

THE STATE BOARD OF EDUCATION has authorized the College to issue certificates for high school teaching under conditions described on page 104.

DESCRIPTION OF ADMISSION SUBJECTS

The general basis of admission to the College is a principal's recommendation showing the satisfactory completion of a high school course of four years in the subjects designated for admission. The following description of preparatory subjects may be supplemented by correspondence with the Recorder:

ENGLISH.—Preparation in English should cover at least three years, and should have for its objects the ability to read with accuracy, intelligence, and appreciation, and to speak and write not only correctly, but with clearness and fluency. Composition and technical English should take about two-fifths of the time, and Literature the remaining three-fifths. This work should be so given that the student may have an appreciative understanding of the books selected for general or for intensive study, with some knowledge of their authors, and an acquaintance with the character and tendencies of the more important literary epochs. (3 units)

GERMAN.—The elementary study of the language, covering two years of daily recitations. This should include a study of the inflections, word-order, the essentials of syntax, and the force of prefixes and suffixes. The student should read about two hundred pages of secondary school German text, and be able to translate simple sentences from English into German, as well as to speak and understand simple German sentences. (2 units)

FRENCH.—The elementary study of the language, covering two years of daily recitations. This should include a knowl-

edge of the forms of the language, the elements of syntax, and the ability to pronounce correctly. The student should read about four hundred pages of secondary school text, and should be able to translate ordinary French into English and to turn simple English into French. (2 units)

SPANISH.—The elementary study of the language, covering two years of daily recitations. The student should have a knowledge of grammar, including a mastery of the common irregular verbs. He should be able to pronounce correctly and to translate ordinary Spanish into English, and English into Spanish. He should read about two hundred pages of secondary school text. (2 units)

LATIN.—Such a knowledge of the elements of grammar as is offered in a standard preparatory book; the reading of the equivalent of four books of Cæsar, and some practice in composition. The study of Latin is deemed valuable for students planning to take scientific work, as it not only facilitates the acquisition of modern languages, but gives a better understanding of scientific terms. (2 units)

MATHEMATICS.—As this subject is prerequisite to any work in engineering, students should have at their command the fundamental principles of algebra, geometry, and trigonometry. It is advised that the high school course be thoroughly reviewed just before entrance. The following outlines show the scope of adequate preparation:

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 equa-

tions, theory of quadratic equations, inequalities; ratio, proportion and variation; arithmetical, geometrical, and harmonical 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: The general properties of plane figures; the circle, and the measure of angles; areas, regular polygons, and the measure of the circle. The requirements also include original propositions, and problems in the mensuration of plane figures, as well as the usual demonstrated theorems. Stress should be placed on clear thinking, strict reasoning, and accuracy of statement, as well as on the acquirement of geometrical knowledge. (1 unit)

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

Trigonometry: This subject includes the general formulas of plane trigonometry; the theory of logarithmic tables; application to the solution of triangles and of simple problems in heights and distances. (½ 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 the regular use of a text-book in history and a text-book in government; systematic reading of assigned references; and the keeping of a note-book containing maps, concise topical outlines of the most important movements and institutions, summaries of the reference reading, and a few carefully prepared brief papers with bibliographical notes. (1 unit)

Physics.—Preparation may be obtained by a 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. The laboratory note-book should furnish a complete and systematic record of the student's experiments and observations. (1 unit)

CHEMISTRY.—Preparation in chemistry can be obtained only from a year's course including both class-room and laboratory exercises, based upon any of the recognized texts. About four hours a week should be given to individual laboratory work. The course should present an outline of the fundamental principles of general chemistry. The laboratory note-book should give special attention to the record of facts observed and inferences drawn, and the written equation by which the reaction is represented. (1 unit)

REGISTRATION

Registration for the first semester will take place on September 3 and 4, 1917, and for the second semester on January 21, 1918, beginning at nine o'clock. A special fee of two dollars is charged for registration after these dates.

Every student must have the approval of the physical director before his initial registration.

The schedule of studies for each student is made out by the Registration Committee, and the student, after arranging for his tuition, is enrolled by the Recorder. A subject will not be assigned to a student unless the officer of instruction in that subject is satisfied that the applicant is competent to undertake it. No student is admitted to classes without a registration card endorsed by the Recorder.

Any change of schedule is made by the Recorder, and after the first week of the semester involves a fee of one dollar, unless made at the suggestion of the College.

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 classes any student who, in his judgment, has neglected his work, and any student thus excluded shall be recorded as having failed in the subject from which he is excluded.

The following system of notation is used to indicate class standing:

V denotes Marked Distinction,
IV denotes Above Average,
III denotes Average,
II denotes Below Average,
C denotes Conditioned,
F denotes Failed.

Average is defined as the standard, based upon the experience of the instructor as being attainable under normal conditions by about one-half the students.

Conditioned indicates deficiencies that may be made up without actually repeating the subject.

Failed means that credit may be secured only by repeating the subject.

Semester examinations will be held in all subjects unless the officer of instruction in any subject shall

arrange otherwise. No student will be exempt from these examinations. Leave of absence may be obtained only from the Recorder, and can be allowed only for serious cause, such as physical inability to be present. Unexcused absence will count as a failure in the subject.

Special examinations may be arranged by the instructor for students having leave of absence, and must be completed within four weeks from the beginning of the second semester; or, if in work of the second semester, during the week preceding registration.

A condition in any semester's work and all work noted as "Incomplete" must be made up within the time limits prescribed above for special examination, unless the instructor shall give the Recorder contrary notice in writing. Work not so adjusted will be recorded as failure.

A student who is recorded as having failed in a required subject must repeat every such subject with the class next taking it, and such subjects will take precedence in the student's time over those that follow.

Formal reports of class work are prepared at the close of each semester; and intermediate informal reports of first-year work at the middle of each semester. These reports are sent either to students themselves, or to parents and guardians, as arranged.

Students who do not maintain a passing grade in at least thirty units of duly registered work in any semester (exclusive of Military Science and Tactics) will be dropped from the roll. Reinstatement is thereafter a matter for special action of the Faculty.

Students whose work is unsatisfactory by reason of lack of diligence may at any time be asked to withdraw.

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.

Students are held responsible for any carelessness or wilful destruction or waste, and at the close of the year, or upon the severance of their connection with any part of the work of the College, they are required to return immediately all locker keys and other property.

It is taken for granted that students enter the College with serious purpose, and that they will cheerfully conform to its requirements. They are expected to behave with decorum, to observe the regulations of the College, and to pay due respect to its officers. Conduct inconsistent with general good order or harmful to the good name of the College will render a student liable to dismissal. The moral tone is exceptionally good; the honor system prevails at examinations, as well as in the general conduct of students, so that cases requiring severe discipline very rarely occur.

The students are organized into an Association to control matters of general concern, and to deal with such subjects as may be delegated to them by the Faculty. Matters of final and severe discipline are in the hands of the President and such other persons as he may designate.

Disciplinary penalties involve the four grades of pro-

bation, suspension, dismissal, and expulsion. Probation indicates that the student is in danger of exclusion, and that he is not permitted to represent the College 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 College will be ended by it. Expulsion, the highest academic censure, denotes final exclusion from the College.

The following statement is emphatically endorsed as the general policy of the College:

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.

ADVISERS

The Recorder is the general consulting officer for students, co-operating with the President and Dean in matters touching student relations. For the purpose of providing additional means of obtaining friendly advice, each student is assigned to some member of the Faculty who acts as his special adviser. By this arrangement it is not intended, however, that the advisers shall become in

any sense guardians of the students assigned to them, or that students shall be limited in their privilege of conferring with the President or other members of the Faculty.

HYGIENIC SUPERVISION

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.

Dr. Andrew W. Smith, of the University of Michigan, was chosen for the position of Physical Director as being both a competent supervisor of athletic activities and an accredited Doctor of Medicine; the object of the college authorities being to make the good health of all the students a matter of scientific care rather than the specialized development of intercollegiate athletic "teams."

Under the system of Military Instruction recently introduced, all students take adequate outdoor exercise daily (See page 116). Every new student must have the approval of the Physical Director before his initial registration. Other students must satisfy the Physical Director within two weeks after the beginning of each semester, and at such other times as the Director may indicate, that they are physically qualified to carry the work for which they are registered. Anthropometric charts are drawn in each instance, and kept for future comparison. The Freshmen take a course of lectures on "How to Live." Dr. Smith is a member of the Faculty, which thus keeps in close touch with intercollegiate athletic activities, and is also kept informed of the health

record of individual students. Should a student invite the impairment of health by neglect of prescribed physical exercise, the Faculty will use its discretion in limiting his assignment of courses of study, since a sound body is regarded as being usually fundamental to a sound mind and subsequent success.

THE CLEVELAND LOAN FUND

This Fund was established by Miss Olive Cleveland, now deceased, 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 College, 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 a limited number of 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.

The total earnings of students in the Public Works Scholarships and at the College during the academic year 1915-1916, not including the summer vacation, was

$2740.68. The various kinds of student employment with earnings are classified as follows:

Work at the College:		
In Chemistry Laboratory	$605.36	
In Civil Engineering Work	48.01	
In Electrical Engineering Laboratory	165.96	
In Mechanical Engineering Laboratory	126.03	
In Materials and Hydraulics Laboratories	27.34	
In Physics Laboratory	57.36	
In Library	104.31	
Janitor Service	134.59	
Miscellaneous work about the College	369.90	
Total from direct employment by the College		$1638.86
Employment in the Municipal Light Plant and other City Departments (Public Works Scholarship)		1101.82
Grand Total		$2740.68

TRAVEL SCHOLARSHIP PRIZES

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

The Junior Prize is awarded at each commencement to the member of the Junior class having the best record in scholarship for the Sophomore and Junior years. This prize is $750 cash. In 1916 it was awarded to Mr. Arthur Stert, who spent the vacation visiting the Panama Canal and other points of special interest in the United States and Canada.

The Freshman Prize, consisting in full provision for a journey through the Eastern United States, over a route recommended by the Faculty, is awarded on each com-

mencement day to that member of the Freshman class who has the best record in scholarship for the Freshman year. This prize is $250 cash. The winner of this prize in 1916 was Mr. Frank Russell Capra.

The Faculty, in making awards, take into account considerations of deportment, or good manners, and ability for original work. They also determine the regulations affecting the use of the prizes; and may in some instances permit the Freshman prize to be used for other purposes than travel. No award shall be made in any case when the Faculty deem the record insufficient to justify it.

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, established in 1912 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 106. The winner of this prize in 1916 was Mr. Gene Bryant Heywood.

EXTENSION COURSES

In co-operation with the citizens of Pasadena, the College offers each year Extension Courses in science, literature, and other branches of knowledge, the scientific series being given in conjunction with the Mt. Wilson Solar Observatory of the Carnegie Institution of Washington. These courses now have the invaluable assistance of the Pasadena Music and Art Association.

WEBB LIBRARY

The tower room of Pasadena Hall, designed especially to accommodate a library, is named in honor of Mr. William E. Webb of New York.

This room contains a research collection, and the special library of the Department of Chemistry. These collections include files of the leading engineering, chemical, and other technical journals, both American and foreign.

THE GENERAL LIBRARY

The general library is conveniently located on the main floor of Pasadena Hall, and contains a collection especially adapted to the needs of a college of technology. While the main body of the books is scientific in character there is a generous admixture of history, philosophy, and literature, including the Cooke Loan Collection in German and French Literature. The library is rapidly growing, and a persistent endeavor is made to keep abreast of the times, especially in securing complete files of technical and scientific periodicals. It is open at all convenient hours, under the care of a trained librarian, who, by formal exercises and otherwise, gives instruction and advice to all students. There is also a co-operative arrangement with the Pasadena Public Library, whereby special collections may be brought to the College for the use of the students.

The reading room is a part of the library, and contains current issues of the technical journals, including many foreign publications, with a careful selection of the leading reviews.

Class work in Current Technical Journals is described on page 115.

STUDENT ORGANIZATIONS AND SOCIAL AFFAIRS

The Associated Students exercise general supervision over matters of undergraduate concern, in co-operation with the Faculty (see page 36). Fraternities are debarred. One or two clubs founded on the principles of good fellowship and mutual helpfulness have been organized under authority of the College. There is also an excellent glee club. A student branch of the American Institute of Electrical Engineers was organized in 1911, a similar branch of the American Society of Mechanical Engineers in 1914, and a Chemists' Club in 1916. "The Throop Tech" is issued monthly by the Associated Students.

EXPENSES

Tuition is $150 a year, payable in two equal installments, one at the beginning of each semester. There is also a fee of $1 a year for locker rental, and upon graduation a diploma fee of $10. There are no other fees, but a deposit of $5 is required each year of students in Chemistry, to cover breakage and loss of laboratory materials.

The cost of supplies and of books, most of which will be useful in later professional practice, ranges from $45 to $50 the first year, the larger part of which is required the first semester, and from $15 to $20 a semester thereafter.

No reduction or refund is made to any student who may be suspended or expelled, or who may leave without a reason that shall be deemed valid, nor is any refund allowed for attendance equaling or exceeding three-quarters of a semester.

DORMITORY

The College has provided on the campus a modern dormitory, of California bungalow type, two stories in height, with large, airy, and well-lighted rooms for about sixty students—several of the rooms having sleeping porches—and with attractive dining room, living room, and recreation rooms. A plan of co-operative management between the College and the students has been adopted, in accordance with which the College rents the rooms to the students and is responsible for their care, while the meals are under the control of the students themselves through the student manager, the dining room being managed as a co-operative club. Table board is furnished to the students living in the dormitory, and to other students and members of the Faculty as well.

Room rents average about $60 for the academic year, the minimum being $45 and the maximum $85. The cost of table board is about $4.75 a week. Each student in the dormitory is required to make a deposit of $10 at the opening of the college year to cover any possible damage to dormitory property.

Each student in the dormitory is expected to provide for his own use the following articles: Three sheets, 1 bed spread, blankets (for single bed), 3 pillow cases, 3 hand towels, and 3 bath towels.

A resolution of the Board of Trustees provides that in no case shall more than ten students be domiciled together in any quarters except the College Dormitory.

Description of Courses

The courses offered by the College include Electrical, Mechanical, Civil, and Chemical Engineering, Chemistry, Engineering and Economics, and General Courses, all leading to the degree of Bachelor of Science. For graduate work, see pages 89, 94, 95.

ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING

Nearly a century ago Tredgold defined engineering as "the art of directing the great sources of power in nature for the use and convenience of man." This definition is broad enough to cover all classes of engineering work, as it recognizes that the fundamental truths of nature must first be discovered by scientific investigation and then put to useful work by intelligent direction.

The fundamental scientific principles are the same for these three branches of engineering. Narrow specialization on the part of undergraduates is not encouraged for the reason that necessary fundamental subjects would be omitted thereby and such specialization often might be misplaced. The desire is rather to lay first a broad and deep foundation in the subjects forming the basis of engineering. After two years devoted to thorough preparation in such subjects as Mathematics, Physics, Chemistry, Drawing, English, and German, French or Spanish, the student may differentiate according to his aptitude and ambition. Students whose chief interest is in the applications of electrical energy will take Electrical Engineering; those who are interested in other forms of power and in the design of machinery will take Mechanical Engineering; those whose aptitude lies in the field of construction will take up Civil Engineering. The pro-

fessional courses in these three branches necessarily diverge more or less in the later years, each laying particular emphasis on problems peculiar to itself. On the other hand, there are many engineering subjects in the advanced years common to all three branches, for the Electrical, Mechanical, and Civil Engineering students all take courses in Surveying, Mechanism, Applied Mechanics, Strength of Materials, Hydraulics, Structural Design, Electrical Engineering, Heat Engines, City Planning, and Public Utilities. It is the aim of the curriculum during the last two years to link up and definitely correlate the different fundamental studies with their varied applications to engineering science. Schedules of these courses are printed on pages 56-59.

CHEMISTRY AND CHEMICAL ENGINEERING

The courses in Chemistry and Chemical Engineering prepare men to conduct those manufacturing processes that deal with the production of materials of various kinds—such, for example, as petroleum products, cements, sugar, paper, soap, fertilizers, leather, drugs, and chemicals. The courses include, in addition to the usual studies in the humanities and in physics, mathematics, and drawing, a thorough training in the various branches of chemistry.

The two courses differ from each other in the respects that the Chemical Engineering course includes a considerable amount of instruction in Mechanical and Electrical, as well as Chemical Engineering, while the Chemistry course affords a more thorough knowledge of chemistry and physics, and gives a somewhat more extended training in chemical research. The studies in Mechanical and Electrical Engineering included in the Chemical Engi-

neering course give the graduate a knowledge of the fundamental principles of machinery used in the chemical industries, and will greatly assist him in operating such machinery, in handling mechanical and electrical power, and in directing the construction of the simpler forms of apparatus used in chemical industry. The additional knowledge of chemistry and physics, and the training in research which the Chemistry course affords will, on the other hand, more directly fit its graduates to carry on the research which is essential to the development of chemical industries.

The course in Chemistry also serves to prepare men for teaching positions in colleges and high schools, and for research positions in government laboratories and universities.

Descriptions of the subjects of instruction are given on pages 84 to 89 inclusive. For the language requirement in the chemical engineering and chemistry courses, see foot note (1), page 56.

Bulletin No. 61, on Industrial Research in America as illustrated especially by Chemistry, may be had on application to the Recorder.

ENGINEERING AND ECONOMICS

This course should not be confused with the courses in commerce offered by various universities and colleges. Engineering is its basis, students taking four-fifths of the subjects offered in the Engineering courses described on pages 56-59, the remainder of their time being devoted to a scientific study of the principles of commerce and industry. It is designed to provide adequate education for students who, while desiring a systematic training in the applied sciences, have interests and aptitudes

which fit them for positions on the business side of manufacturing and transportation enterprises, rather than for specialized engineering.

The course includes (1) the instruction common to all courses, in literature, science, and mathematics; (2) an assignment of engineering studies in one of the three groups: Electrical, Mechanical, or Civil Engineering; and (3) a selected group of subjects in economics and business. The subjects in group 3 may be briefly described as follows:

Economics, being fundamental to all that follows, provides a general survey of the principles governing the production, distribution, and consumption of wealth; while the study of Economic History acquaints the student with economic problems and forces as effecting the development of the United States of America. Business Law is designed to provide such knowledge of the law as will give a general understanding of legal rights and duties in ordinary circumstances and will lead to precautionary measures, whenever business may threaten to depart from tried routine, so as to avoid the expense and trouble arising from a fully developed emergency. Instruction in Banking and Securities, Accounting and Statistics, Transportation, Taxation, and Cost Accounting deals thoroughly with the broad outlines and fundamental principles of these several subjects. The work in Commercial Organization aims to ground students in the principles underlying modern business as illustrated by concrete examples offered by an examination of typical American industries; while that in Industrial Management involves a consideration of the present tendencies of industrial organization, its forms and problems, together with a critical study of the recent applications of system. Students will be

required to inspect well-organized factories and business establishments and to prepare written reports thereon. The lectures in Psychology and Ethics will deal with the fact that a knowledge of men is the most important element in education, and that in the relations of men perfect honesty is the only basis of real success.

This course in Engineering and Economics is one of the General Courses, and leads, like all others, to the degree of Bachelor of Science.

The schedule of this course is given on pages 62 and 63, following.

GENERAL COURSES

General Courses are provided primarily for those who may desire 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 standards and with the thoroughness of a professional school. They also afford an opportunity for several other classes of students: those who may desire to engage in scientific research, those who plan to become teachers of science, and those who may desire some scientific preparation for a business career.

Students in General Courses must take all the required work common to all courses, in addition to their major subject. The remainder of their work is prescriptive, varying in accordance with their respective plans and requirements. This work must be arranged subject to the approval of the Faculty so as to form a consistent whole.

GENERAL PLAN

Throop College sets applied sciences at the center of its undergraduate courses, but surrounds these with the

more essential humanities. Architecturally, this emphasis is expressed by Alexander Stirling Calder's heroic figures of the Humanities, grouped with Energy and Science over the archways of the main building. The College holds that certain so-called "cultural" studies are indeed most practical and needful. It believes that the English language is the chief tool in the engineer's kit; and requires four years' study of it, instead of the one-year requirement of most engineering courses elsewhere. It believes that the young engineer must also know at least one continental language, with its appropriate background of history, besides American history and civics and business law. It believes that his first object should be serviceable citizenship, and that in this direction he has unusual opportunities—as a "civic engineer," as has been said. It has no electives, but many "prescriptives," appointed according to individual talents or needs. It has one instructor for every group of six students, and gives much attention to research. It requires fifteen units for admission and four years of hard work for graduation. It is not a place for boys to play, but for men to work in.

A member of the Board of Trustees of Throop College has said:

> It is a practice in which educational critics sometimes indulge, to contrast science and art as opposed by their very nature to one another. Science is stigmatized as the symbol of a harsh materialism, and as the destroyer of those essential beauties of art and life which in reality stand above all means of analysis. In the eyes of such critics, science would banish all beauty from the world, by seeking to condense the mystery of poesy into a formula, by substituting for the Parthenon an analysis of its curves: in short, by a universal process of dissection and destruction which would leave nothing for the imagination to enjoy.

But such views are based upon a superficial estimate of science, which has much in common with art. Its highest conceptions and its greatest pleasures are equally those of the imagination, the indispensable source of all great advances. Its modes of progress, though they may seem mechanical and formal to those who do not look beneath the surface, are not more materialistic than the brush-work of the painter or the stone-cutting of the sculptor. Its results, so often regarded as merely analytic and destructive, are in the end synthetic and constructive, appealing to the imagination as only the greatest works of art can do.

A Gothic cathedral, in all its sombre splendor, affords to the imagination no more superb picture than the primeval nebula, condensing toward the central sun, and giving rise to the planets of the solar system. The Parthenon itself, even before its walls were demolished and its sculptures removed, offered no more powerful appeal than the march of evolution and the development of living things since the first appearance of life upon the earth. And if it be argued that these conceptions of science are merely expressions of natural phenomena, grasped in the large, and freed from the dross of incident and detail, may not the same be said of the greatest achievements of painting and of sculpture?

But the contributions of science to the beauty of the world are not confined to these products of synthetic reasoning. In every direction it has multiplied our perception and enlarged our vision. In distant space it has found luminous clouds of exquisite spiral structure, globular clusters of tens of thousands of stars, and revolving systems indirectly perceptible by the influence of their motion on the nature of light. It has transformed the mud from the bottom of the sea into forms as perfect as snow crystals, the skeletons of microscopic beings of former ages. It has revealed beneath the green scum of stagnant pools the infinitely varied and delicately beautiful creatures of a living world as marvelous as the stellar universe. It has pierced beyond this world into the atom itself, and shown us the thousands of electrons, whirling in orbits, which in endless combinations form systems more varied and complex than their analogues among the stars. Even analysis, then,

may yield beauty, and he who penetrates to the heart of nature will find the powers of his imagination and his pleasure in all forms of beauty—not least those of literature and art —expanding as he goes.

PLAN OF INSTRUCTION

Graduate courses in Chemistry and Physics are offered in connection with research directed by Dr. Arthur A. Noyes in Chemistry and Dr. Robert A. Millikan in Physics (see pages 89, 94).

All of the undergraduate courses as far as possible 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 technique 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 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 libraries to the fullest extent, and particular stress is placed upon acquaintance with contemporary progress and practice through a study of catalogues and by special courses in current technical journals. To develop expression and breadth of view, advanced students may be required to prepare and deliver before the student body stated reviews of recent developments and tendencies in their fields of study. 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 College has been peculiarly fortunate in securing the presence of eminent engineers and other specialists to address the assemblies, as the influence of leading personalities is an invaluable supplement to its curriculum. The rapid development of a great industrial environment about Los Angeles affords unlimited opportunities for visits to all kinds of engineering works in operation and in process of construction, to chemical and other 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 refining petroleum and other typical products, in making cement, in pumping, and in developing power by means of hydro-electric plants.

GRADUATION

For graduation, a total of 398 units is required.

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 College, and may not be published except by its authority.

The degree conferred by the College 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 required 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. At some time during his course the student should make practical application of text-book theories by undertaking actual labor connected with his future profession; and the College affords aid in this direction by such agencies as the Public Works Scholarship Fund, described elsewhere. Summer work of this character is warmly encouraged, being recognized as an important supplement to the instruction offered at the College.

Schedules of Courses

EXPLANATION OF TERMS

The "subject number" in the following tables refers to the description of subjects beginning on page 65.

The number of units given in each semester for any course is the total number of hours per week required in that course, including class and laboratory work and the estimated time for preparation.

The term "prescriptive" denotes, (1): Studies that may be assigned by the Faculty to determine the specific direction of some of the courses. For example, students in Engineering and Economics whose interest lies in the applications of electrical energy take a group of subjects in Electrical Engineering. (2): Subjects assigned to a student according to the needs of his probable future environment, as in the case of advanced courses in Modern Language. (3): Subjects assigned in a special case because of discovered deficiencies in previous training. For example, students needing further work in English of the type of Course 601-602 may be advised to take "Special Composition" or "Spelling" in addition to regular sophomore work.

The year is divided into semesters, beginning in September and January. The normal work of a semester amounts to about 48 units in Engineering and General Courses (exclusive of Military Science and Tactics), 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.

ALL COURSES

FIRST YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
I. FRESHMAN YEAR					
1ST SEMESTER					
REQUIRED					
English	601	3	0	3	6
French, German or Spanish	655, 675, 695	3	0	4	7
Advanced Algebra	453	2	0	2	4
Computation	452	2	0	2	4
Inorganic Chemistry	301	3	6	3	12
Mechanical Drawing and Descriptive Geometry	701	0	5	0	5
Freehand Lettering	721	0	2	0	2
General Problems	771	1	0	1	2
Shop Work	741 or 742	0	4	0	4
Military Science and Tactics		1	2	1	4
PRESCRIPTIVE					
Plane Trigonometry	451	3	0	3	6
French[1]	651	3	0	4	7
German[1]	671	3	0	4	7
Spanish[1]	691	3	0	4	7
Chemistry	301a	4	6	6	16
Freehand Sketching	723	0	1	0	1
2ND SEMESTER					
REQUIRED					
English	602	3	0	3	6
French, German or Spanish	656, 676, 696	3	0	4	7
Inorganic Chemistry	302	1	0	1	2
Qualitative Analysis	311	2	6	2	10
Analytical Geometry	454	3	0	6	9
Mechanical Drawing and Descriptive Geometry	702	0	6	0	6
Freehand Lettering	722	0	1	0	1
Spherical Trigonometry[2]	455	2	0	2	4
General Problems[3]	772	1	0	1	2
Shop Work	741 or 742	0	4	0	4
Military Science and Tactics		1	2	1	4
PRESCRIPTIVE					
Elementary Analysis	456	2	0	2	4
French[1]	652	3	0	4	7
German[1]	672	3	0	4	7
Spanish[1]	692	3	0	4	7
Freehand Sketching	724	0	1	0	1

1—If not offered for admission, either French 651-652, German 671-672, or Spanish 691-692 is required, and the language thus begun must be continued through the Junior year. In the Chemistry course two years of German are required if French is offered for entrance, but if German is offered for entrance one year of German and one year of French are required. The language requirement for the Chemical Engineering course is the same as for the Chemistry course, except that a year of Spanish may be substituted for the one year of French.

2—In the Civil Engineering course.

3—Not required in the Civil Engineering course.

ALL COURSES

SECOND YEAR

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
II. SOPHOMORE YEAR					
1ST SEMESTER					
REQUIRED					
English	603	2	0	2	4
French, German or Spanish	657, 677, 697	3	0	4	7
Calculus	457	3	0	5	8
Physics	401	3	0	5	8
Physical Laboratory	402	0	4	0	4
Mechanism[1 2 3 4]	150	2	2	3	7
Surveying[1 2 3]	201	2	3	2	7
Machine Drawing[3]	703	0	3	0	3
Shop Work[1 2]	743	0	4	0	4
Qualitative Analysis[4 5]	312	1	9	1	11
Military Science and Tactics		1	2	1	4
PRESCRIPTIVE					
French[6]	653	3	0	4	7
German[6]	673	3	0	4	7
Spanish[6]	693	3	0	4	7
American Government	588	2	0	2	4
Special Composition	611	1	0	2	3
Machine Drawing	705	0	3	0	3
Freehand Sketching	725	0	1	0	1
2ND SEMESTER					
REQUIRED					
Argumentation and Public Speaking	604	2	0	2	4
French, German or Spanish	658, 678, 698	3	0	4	7
Calculus	458	3	0	5	8
Physics	403	3	0	5	8
Physical Laboratory	404	0	4	0	4
Applied Mechanics[1 2 3 4]	251	5	0	5	10
Surveying[3]	202	2	3	2	7
Machine Drawing[1 2]	706	0	3	0	3
Shop Work[1 2]	744	0	4	0	4
Quantitative Analysis[4 5]	316	1	6-9	1	8-11
Military Science and Tactics		1	2	1	4
PRESCRIPTIVE					
French[6]	654	3	0	4	7
German[6]	674	3	0	4	7
Spanish[6]	694	3	0	4	7
English	609	2	0	2	4
Special Composition	612	1	0	2	3
Freehand Sketching	726	0	1	0	1

1—In Electrical Engineering Course.
2—In Mechanical Engineering Course.
3—In Civil Engineering Course.
4—In Chemical Engineering Course.
5—In Chemistry Course.
6—See note 1, page 56.

ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING
THIRD YEAR[1]

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
III. JUNIOR YEAR					
1ST SEMESTER					
REQUIRED					
All Courses					
English	605	2	0	2	4
Economics	551	2	0	3	5
Strength of Materials	252	4	0	6	6
Hydraulics	270				4
Materials of Construction	260	1	0	0	1
Direct Currents	100	3	0	4	7
Direct Current Laboratory	101	0	3	1	4
Engineering Journals	751	1	0	1	2
Electrical Engineering					
Electricity and Magnetism	405	1	0	2	3
Electrical Measurements	406	1	0	1	2
Electrical Measurements	407	0	2	0	2
Testing Materials Laboratory	261	0	5	0	5
Graphic Statics	253	0	4	0	4
Mechanical Engineering					
Electricity and Magnetism	405	1	0	2	3
Testing Materials Laboratory	261	0	5	0	5
Graphic Statics	253	0	4	0	4
Valve Gears and Governors	152	1	2	1	4
Civil Engineering					
Highway Engineering	205	1	0	2	3
Theory of Structures	217	3	3	5	11
Testing Materials Laboratory	262	0	3	0	3
2ND SEMESTER					
REQUIRED					
All Courses					
English	606	2	0	2	4
Economic History	552	1	0	3	4
Hydraulic Motors	271	2	0	2	4
Hydraulics Laboratory	272	0	6	0	3
Hydraulic Machinery	273				3
Alternating Currents	102	3	0	4	7
Engineering Journals	752	1	0	1	2
Electrical Engineering					
Alternating Current Laboratory	103	0	6	0	6
Thermodynamics	160	2	0	2	4
Machine Design	153	2	4	2	8
Mechanical Engineering					
Alternating Current Laboratory	103	0	6	0	6
Thermodynamics	160	2	0	2	4
Machine Design	153	2	4	2	8
Civil Engineering					
Theory of Structures	218	3	0	5	8
Railway Surveying and Engineering	206	3	3	5	11
Electrical Laboratory	143	0	3	1	4

1—For prescriptive subjects see page 64.

ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING
FOURTH YEAR[1]

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
IV. SENIOR YEAR					
1ST SEMESTER					
REQUIRED					
All Courses					
English	607	1	0	2	3
Education	590	1	0	2	3
Business Law	575	2	0	2	4
Public Utilities	225	1	0	1	2
Engineering Journals	753	1	0	1	2
Thesis	800				3
Electrical Engineering					
Alternating Current Analysis	104	3	0	6	9
Alternating Current Laboratory	105	0	6	0	6
Induction Machines	110	2	0	4	6
Electric Lighting and Power Distribution	112	2	0	3	5
Steam Laboratory	175	0	3	1	4
Thermal Prime Movers	171	2	0	3	5
Mechanical Engineering					
Thermal Prime Movers	161	4	0	6	10
Advanced Machine Design	154	2	6	3	11
Steam Laboratory	165	0	6	2	8
Electric Lighting and Power Distribution	112	2	0	3	5
Civil Engineering					
Reinforced Concrete	219	2	0	4	6
Structural Design	221	0	9	0	9
Irrigation and Water Supply	215	3	0	5	8
Sewerage and Drainage	209	2	0	4	6
Mineralogy	525	1	2	1	4
2ND SEMESTER					
REQUIRED					
All Courses					
English	608	1	0	2	3
Modern Europe	587	2	0	3	5
Accounting	561	2	0	2	4
City Planning	226	1	0	1	2
Engineering Journals	754	1	0	1	2
Thesis	800				9
Electrical Engineering					
Electrical Engineering	106	4	0	6	10
Electrical Engineering Laboratory	107	0	3	0	3
Power Plant Engineering	163	3	0	3	6
Fuel and Lubricant Laboratory	166	0	3	0	3
Mechanical Engineering					
Power Plant Engineering	162	3	4	3	10
Mechanical Engineering Design	155	1	4	1	6
Mechanical Engineering Laboratory	170	0	3	1	4
Fuel and Lubricant Laboratory	166	0	3	0	3
Civil Engineering					
Masonry Structures	220	2	0	3	5
Civil Engineering Design	222	0	9	0	9
Heat Power Engineering	168	2	0	2	4
Geology	526	2	0	2	4

1—For prescriptive subjects see page 64.

CHEMISTRY AND CHEMICAL ENGINEERING

THIRD YEAR[1]

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
III. JUNIOR YEAR					
1ST SEMESTER					
REQUIRED					
Both Courses					
English	605	2	0	2	4
Economics	551	2	0	3	5
Organic Chemistry	351	3	0	5	8
Organic Chemistry Laboratory	353	0	6	0	6
Theoretical Chemistry	331	3	0	5	8
Theoretical Chemistry Laboratory	333	0	3	2	5
Chemical Engineering					
Strength of Materials	252	4	0	6	6
Hydraulics	270				4
Materials of Construction	260	1	0	0	1
Testing Materials Laboratory	262	0	3	0	3
Chemistry					
Electricity and Magnetism	405	1	0	2	3
Electrical Measurements and Methods	406	1	0	1	2
Electrical Measurements	407	0	2	0	2
PRESCRIPTIVE					
Quantitative Analysis	317	0	6	0	6
Mineralogy	525	1	2	1	4
Research Reports	391	1	0	0–1	1–2
2ND SEMESTER					
REQUIRED					
Both Courses					
English	606	2	0	2	4
Economic History	552	1	0	3	4
Organic Chemistry	352	3	0	5	8
Organic Chemistry Laboratory	354	0	6	0	6
Theoretical Chemistry	332	3	0	6	9
Theoretical Chemistry Laboratory	334	0	3	2	5
Industrial Chemistry	372	3	0	3	6
Chemical Engineering					
Machine Drawing	706	0	3	0	3
Heat Power Engineering	168	2	0	2	4
Chemistry					
PRESCRIPTIVE					
Geology	526	2	0	2	4
Quantitative Analysis	318	0	6	0	6
Organic Analysis	355	0	4–6	0	4–6
Special Topics in Physical Chemistry	338	2	0	2	4
Research Reports	392	1	0	0–1	1–2

1—For first and second year schedules of these courses see pages 56, 57.
For the language requirement see foot-note (1) page 56.
For other prescriptive subjects see page 64.

CHEMISTRY AND CHEMICAL ENGINEERING

FOURTH YEAR[1]

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
IV. SENIOR YEAR					
1ST SEMESTER					
REQUIRED					
Both Courses					
English	607	1	0	2	3
Education	590	1	0	2	3
Business Law	575	2	0	2	4
Theoretical Chemistry	335	3	0	4	7
Theoretical Chemistry Laboratory	336	0	2	0	2
Industrial Chemistry	373	3	0	3	6
Technical Analysis	321	1	6	2	9
Research Reports	391	1	0	1	2
Thesis	800				4–6
Chemical Engineering					
Direct Currents	100	3	0	4	7
Direct Currents Laboratory	101	0	3	1	4
Chemistry					
PRESCRIPTIVE					
Quantitative Analysis	317	0	6	0	6
Direct Currents	100	3	0	4	7
Direct Currents Laboratory	101	0	3	1	4
Food Analysis	323	0	6	0	6
Organic Chemistry Laboratory	357	0	3–6	0	3–6
2ND SEMESTER					
REQUIRED					
Both Courses					
English	608	1	0	2	3
Modern Europe	587	2	0	3	5
Accounting	561	2	0	2	4
Research Reports	392	1	0	1	2
Thesis	800				12–18
Chemical Engineering					
Alternating Currents	102	3	0	4	7
Electrical Laboratory	143	0	3	1	4
Chemical Engineering	378	2	6	2	10
PRESCRIPTIVE					
Special Topics in Physical Chemistry	338	2	0	2	4
Chemistry					
PRESCRIPTIVE					
Alternating Currents	102	3	0	4	7
Electrical Laboratory	143	0	3	1	4
Food Analysis	324	0	6	0	6
Technology of Petroleum	362	1	3	2	6
Special Topics in Physical Chemistry	338	2	0	2	4

1—For other prescriptive subjects see page 64.

ENGINEERING AND ECONOMICS
THIRD YEAR[1]

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
III. JUNIOR YEAR					
1ST SEMESTER					
REQUIRED					
English	605	2	0	2	4
Economics	551	2	0	3	5
Strength of Materials	252	4	0	6	6
Hydraulics	270				4
Direct Currents	100	3	0	4	7
Direct Current Laboratory	101	0	3	1	4
Materials of Construction	260	1	0	0	1
Testing Materials Laboratory	262	0	3	0	3
Accounting	563	3	0	3	6
Statistics	553	1	0	1	2
Engineering Journals	751	1	0	1	2
PRESCRIPTIVE					
Electrical Engineering					
Electricity and Magnetism	405	1	0	2	3
Graphic Statics	253	0	4	0	4
Mechanical Engineering					
Valve Gears and Governors	152	1	2	1	4
Graphic Statics	253	0	4	0	4
Civil Engineering					
Highway Engineering	205	1	0	2	3
Graphic Statics	253	0	4	0	4
or					
Theory of Structures	217	3	3	5	11
2ND SEMESTER					
REQUIRED					
English	606	2	0	2	4
Economic History	552	1	0	3	4
Hydraulics Laboratory	272	0	3	0	3
Alternating Currents	102	3	0	4	7
Electrical Laboratory	143	0	3	1	4
Thermodynamics	160	2	0	2	4
Banking	565	2	0	2	4
Securities	566	1	0	1	2
Business Law	576	2	0	3	5
Engineering Journals	752	1	0	1	2
PRESCRIPTIVE					
Electrical Engineering					
Machine Design	153	2	4	2	8
or					
Hydraulic Motors	271	2	3	2	7
Hydraulic Machinery	273				
Mechanical Engineering					
Machine Design	153	2	4	2	8
or					
Hydraulic Motors	271	2	3	2	7
Hydraulic Machinery	273				
Civil Engineering					
Theory of Structures	218	3	0	5	8
or					
Railway Surveying and Engineering	206	3	3	5	11
or					
Hydraulic Motors	271	2	3	2	7
Hydraulic Machinery	273				

[1]—For first and second year schedules of this course, see pages 56, 57.
For other prescriptive subjects see page 64.

ENGINEERING AND ECONOMICS
FOURTH YEAR[1]

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
IV. SENIOR YEAR					
1ST SEMESTER					
REQUIRED					
English	607	1	0	2	3
Education	590	1	0	2	3
Public Utilities	225	1	0	1	2
Commercial Organization	581	2	0	3	5
Industrial Management	583	2	0	3	5
Business Law	577	2	0	3	5
Transportation	585	2	0	2	4
Engineering Journals	753	1	0	1	2
Thesis	800				3
PRESCRIPTIVE					
Electrical Engineering					
Alternating Current Analysis	104	3	0	6	9
Alternating Current Laboratory	105	0	6	0	6
Mechanical Engineering					
Steam Laboratory	165	0	6	2	8
Thermal Prime Movers	161	4	0	6	10
Civil Engineering					
Irrigation and Water Supply	215	3	0	5	8
Sewerage and Drainage	209	2	0	4	6
or					
Reinforced Concrete	219	2	0	4	6
Structural Design	221	0	9	0	9
2ND SEMESTER					
REQUIRED					
English	608	1	0	2	3
Modern Europe	587	2	0	3	5
City Planning	226	1	0	1	2
Commercial Organization	582	2	0	3	5
Industrial Management	584	2	0	3	5
Taxation	554	1	0	1	2
Cost Accounting	564	2	0	3	5
Engineering Journals	754	1	0	1	2
Thesis	800				10
PRESCRIPTIVE					
Electrical Engineering					
Power Plant Engineering	163	3	0	3	6
Electrical Engineering Laboratory	107	0	3	0	3
Mechanical Engineering					
Machine Design	153	2	4	2	8
or					
Mechanical Engineering Design	155	1	4	1	6
Civil Engineering					
Power Plant Engineering	163	3	0	3	6
or					
Railway Surveying and Engineering	206	3	3	5	11
or					
Hydraulic Motors Hydraulic Machinery	271 273	2	3	2	7

1—For other prescriptive subjects see page 64.

PRESCRIPTIVE STUDIES[1]

THIRD AND FOURTH YEARS

SUBJECTS	Subject Number	Hours per Week			Units
		Class	Laboratory	Preparation	
III. JUNIOR YEAR					
1ST SEMESTER					
Differential Equations	459	2	0	4	6
Municipalities	589	1	0	1	2
Advanced French II	659	2	0	3	5
Advanced German II	679	2	0	3	5
Advanced Spanish II	699	2	0	3	5
Eighteenth Century Literature	609	2	0	2	4
Mineralogy	525	1	2	1	4
Chemistry (see pages 84-89)					
2ND SEMESTER					
Applied Heat	410	1	3	3	7
Differential Equations	460	2	0	4	6
Least Squares	461	2	0	3	5
Advanced French II	660	2	0	3	5
Advanced German II	680	2	0	3	5
Advanced Spanish II	700	2	0	3	5
Geology	526	2	0	2	4
Chemistry (see pages 84-89)					
IV. SENIOR YEAR					
1ST SEMESTER					
Applied Optics	412	1	3	3	7
Advanced Calculus	463	2	0	4	6
Advanced French III	661	2	0	3	5
Advanced German III	681	2	0	3	5
Electrical Communication	108	2	0	3	5
Geology	527	2	0	2	4
2ND SEMESTER					
Advanced Calculus	464	2	0	4	6
Advanced French III	662	2	0	3	5
Advanced German III	682	2	0	3	5
Advanced Electrical Engineering	109	2	0	3	5

[1]—Any study not required in a course may be treated as prescriptive.

Description of Subjects

INDEX

ENGINEERING

The work listed in the three branches of engineering described in the pages immediately following is designed to give the student sound training, both theoretical and practical, in those fundamental subjects upon which professional practice is based. He is familiarized with the use of engineering apparatus and methods, and with the usual problems of practice. Particular care is taken to enforce the application of the principles taught.

ELECTRICAL ENGINEERING

100. Direct Currents.—Theory and practice of direct current machinery, and measuring instruments. Numerous problems are solved. Text: Elements of Electrical Engineering, Franklin and Esty, Vol. I. Required in Electrical, Mechanical and Civil Engineering courses, first semester junior year, and in the Chemical Engineering course, first semester, senior year. (7 units)

101. Direct Current Laboratory.—Uses of measuring instruments, determination of direct current machinery char-

acteristics, efficiency tests, and the operation of direct current motors and generators, singly and in multiple; arc lamp operation. Required in Electrical, Mechanical, and Civil Engineering courses, first semester, junior year, and in the Chemical Engineering course, first semester, senior year. (4 units)

102. ELEMENTARY ALTERNATING CURRENTS. — Elementary study of alternating currents by analytical and graphical methods. Measuring instruments; inductance and capacity, harmonic electromotive force and harmonic current; problems of reactive circuits; resonance; problems of coils in series and multiple; single and polyphase alternators; single and polyphase systems; synchronous motors; simple rotary converters; transformers; induction, and single phase motors. Numerous problems are worked. Text: Elements of Electrical Engineering, Franklin and Esty, Vol. II. Required in Electrical, Mechanical and Civil Engineering courses, second semester, junior year, and in the Chemical Engineering course, second semester, senior year. (9 units)

103. ALTERNATING CURRENT LABORATORY.—Supplementary to 102. Three wire generators and systems; analysis of characteristics, determination of efficiency regulation and rating, and other tests on alternating current generators, motors and transformers; calibration of indicating and recording meters. Required in Electrical and Mechanical Engineering courses, second semester, junior year. (6 units)

104. ALTERNATING CURRENT ANALYSIS.—Advanced study of the magnetic and electric circuits; problems of the electrostatic and electromagnetic fields; study of magnetic materials, solution of problems involving the symbolic method and complex notation; analysis of electromotive force, and current, nonsinusoidal wave forms; use of the oscillograph. Required in Electrical Engineering courses, first semester, senior year. (9 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; use of the oscillograph; testing of magnetic materials. Required in Electrical Engineering courses, 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. Required in Electrical Engineering courses, second semester, senior year. (10 units)

107. Electrical Engineering Laboratory and Design.—The design of some electrical apparatus, the data for which are obtained from tests made on machines in the laboratory. Required in Electrical Engineering courses, 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. Advanced Electrical Engineering.—A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors. Prescriptive, second semester, senior year. (5 units)

110. Induction Machines.—An advanced study of the stationary transformer, with special emphasis upon problems of multiple operation which involve problems of polyphase polarity, together with single and polyphase multiple circuits; theory

and operation of the induction motor; single phase alternating current motors. Required in Electrical Engineering courses, first semester, senior year. (6 units)

112. ELECTRIC LIGHTING AND POWER DISTRIBUTION.—Electric distribution and wiring; calculation of simple alternating current circuits; installation and operation costs and selling price of electric power. Required in Electrical and Mechanical Engineering courses, first semester, senior year. (5 units)

143. ELECTRICAL LABORATORY.—Abridged study of alternating current laboratory similar to 103, but adapted to the needs of Civil and Chemical Engineering students. Required in the Civil Engineering and Engineering and Economics courses, second semester, junior year, and in the Chemical Engineering course, second semester, senior year. (4 units)

[SEE ALSO SUBJECTS 150, 153, 160, 163, 171, 175, 201, 225, 226, 251, 252, 253, 261, 270, 271, 272, AND 273.]

ELECTRICAL ENGINEERING EQUIPMENT

The apparatus has been so installed as to permit the arrangement of the laboratories as a system of power distribution if desired. Nearly all the machines used for testing purposes are of one rating, that is, the motors are 10 horse-power and the generators have a capacity of 7½ kilowatts, these being standard commercial sizes which are carried in stock. 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 two-unit Westinghouse motor-generator set consisting of a 35 horse-power, 125 volt, 1000-1200 r. p. m. motor and a 30 k. v. a., 2200 volt alternator, both mounted on the same bed plate; one three-panel white marble switchboard for building distribution, equipped with knife switches, cartridge fuses, and watt-hour meters only; one nine-panel natural black General Electric switch board arranged as follows: Panels 1 and 6 have plug terminals by means of which leads from one set of testing machines may be connected to the leads of any other set or to any of the sources of laboratory power supply; panel 2 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; panel 3 is equipped with a 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; panels 4 and 5 are each equipped with field control, ammeter, voltmeter, circuit breakers and the necessary switches to enable them to serve as the control panels for the two direct current generators of the three unit motor-generator set; panel 7 is similar to panels 4 and 5, but has in addition a starting switch so that it may be used to control the direct current unit of the Westinghouse two unit motor-generator set when it is operating either as a motor or a generator; panel 8 is equipped with alternating current voltmeter and ammeter, two three-pole oil switches, exciter and generator field control, and synchronizer plugs for use in the control of the alternator of the two unit Westinghouse set when operating either as an alternator or synchronous motor; two 7.5 kilowatt compound Westinghouse direct-current generators, usable also as motors; one 10 horse-power four-pole series or shunt Westinghouse motor, usable also as a generator; one General Electric 6 3-4 kilowatt regulating-pole rotary converter, with connections for one, three, and six phases, equipped with speed limit and end play devices; one Westinghouse 7.5 kilowatt rotary converter with connections for one, two, three, and six phases and usable as a regular or inverted rotary converter, double-current generator, synchronous or direct current-motor, and a three-wire direct-current generator; two inter-pole, variable speed, 10 horse-power General Electric motors; one three-phase, 10 horse-power, 110 volt, 50 cycle Holtzer-Cabot synchronous motor, with field arranged for use as a synchronous condenser, or for reactance, and provided with bridges to make it self-starting; 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 one, two, three

and six phases, and usable also as a synchronous motor; one General Electric A.H.B. alternating current 7.5 k. v. a. laboratory set; 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 1.9 kilowatt three-phase induction-type feeder-regulator; 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; three 10 k. v. a. cruciform type Westinghouse transformers arranged with suitable switchboards, as a substation for use as a testing station or as a substation to change the 2200 volt three-phase current supplied by the Westinghouse alternator to 110/220 or 440 volts as desired; miscellaneous switches; circuit breakers; lamp boards; models; wiring supplies, tables, etc.

PHOTOMETRIC APPARATUS.—A Leeds and Northrup station photometer, with Lummer-Brodhun screen, motor driven lamp rotor, and other fittings; a Macbeth portable illuminometer; standard lamps certified by Bureau of Standards; alternating and direct-current arc lamps.

CALIBRATING INSTRUMENTS.—A Leeds and Northrup deflection potentiometer, designed by the United States Bureau of Standards, with certified standard cell and shunts; Siemens-Halske precision alternating and direct-current voltmeter, range 75-150 volts; three Siemens-Halske precision ammeters for currents varying from 1-10 to 200 amperes; standard Model-5 Weston voltmeter; standard Model-5 milli-voltmeter with shunts for determining current values; milli-ammeter.

MEASURING INSTRUMENTS.—A General Electric Company oscillograph, with attachments; a Richard Müller-Uri cathode ray tube for cathode ray oscillograph work; an Epstein hysteresis tester, made by the General Electric Company; 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 heavy direct currents—the trade names for some of the types being the Ameri-

can, Hartmann & Braun, Keystone, Thompson, Weston, and Whitney; three Weston indicating wattmeters; one Westinghouse one, two, and three-phase indicating wattmeter; three General Electric wattmeters for low power factor measurements; Stanley, Westinghouse, and other watt-hour meters; one Westinghouse and one General Electric power-factor meter; one General Electric synchronism indicator; one General Electric frequency meter, and also four Hartmann & Braun vibrating reed frequency meters; a permeammeter of United States Bureau of Standards pattern, made by Throop students.

HIGH TENSION APPARATUS.—One of the two 125,000 volt transformers being constructed by the Throop students is available for use in the second semester work of this year, and the second one, which will be constructed to operate with this first unit so as to give 250,000 volts, will be ready for use during the year 1917-1918. There is also available for use in high tension work a Weinholtz static machine of the largest size; induction coils, and other necessary apparatus.

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 gearings, belt and chain drive, and the mechanism of machine tools. Class discussion, and drawing board studies. Required in all Engineering courses, first semester, sophomore year. (7 units)

152. VALVE GEARS AND GOVERNORS.—Valve gears as used on steam and internal combustion engines, including plain slide valves, piston valves, double ported valves, and those with riding cut off; reversing gears such as Stephenson, Walschaert, Joy, Marshall and Hackworth; poppet valve gears; governors for valve control, centrifugal and inertia types; governors for internal combustion engines and turbine governors. Recitation and drawing board studies. Required in Mechanical Engineering courses, first semester, junior year. (4 units)

153. MACHINE DESIGN.—A critical study of the problems involved and the best method of solution employed in designing various machines, the choice of material, the arrangement of members to insure accessibility and ease of repair, distribution

of material, the design of bearing surfaces and methods of lubrication to maintain oil film; the proportion of sliding surfaces to prevent uneven wear; calculations of machine fastenings and riveted joints, fly wheels and thick cylinders, shrinkage and forced fits; shafting and cranks for strength and stiffness with torsional or combined stresses; friction couplings, and brakes; spur, friction and helical gears, belts and ropes for power transmission; machine frames. Lectures, recitations and drawing board studies. Required in Electrical and Mechanical Engineering courses, second semester, junior year. (8 units)

154. ADVANCED MACHINE DESIGN.—A continuation of the work in Subject 153, with special reference to the needs of the student; a critical study of many special machines, such as cranes and hoists; punches and modern metal working machines; pumps, blowers, motor trucks. The student is required to design some machine of considerable magnitude involving complex stresses. A study is made of special methods of construction and assembly and of the uses of high grade special steels and alloys and heat treatment. Required in Mechanical Engineering courses, first semester, senior year. (11 units)

155. MECHANICAL ENGINEERING DESIGN.—A continuation of the work in design with the principles applied to the proportioning of parts for steam engines and internal combustion motors, dynamometers, bodies with a high rotative speed. Dynamics of machinery, effects of reciprocating parts, inertia stresses, balancing. A completed design of some machine is required. When desirable the student may choose the design of some special piece of apparatus to be used in an original investigation as the subject of his study. Required in Mechanical Engineering courses, second semester, senior year.
(6 units)

160. THERMODYNAMICS AND HEAT ENGINES.—Principles of thermodynamics, discussion of properties of gases, saturated and superheated vapors, various cycles of vapor engines and

internal combustion engines. Required in Electrical and Mechanical Engineering courses, second semester, junior year. (4 units)

161. THERMAL PRIME MOVERS.—Continuation of 160. Comparison is made of ideal and actual cycles of vapor and external and internal combustion engines. Relative economies of steam engines, turbines and internal combustion engines are discussed. Study is made of flow of vapors and gases through orifices and pipes. Required in Mechanical Engineering courses, first semester, senior year. (10 units)

162. POWER PLANT ENGINEERING.—Study of the apparatus used in power plants of all types, with comparisons of cost of installation and operation. The course includes a study of boilers, heaters, economizers, engines, turbines, condensers, piping, gas producers, refrigeration, and heating. Application is made to the design of a plant for certain given conditions, including building, selection of apparatus and installation drawings. Required in Mechanical Engineering courses, second semester, senior year. (10 units)

163. POWER PLANT ENGINEERING.—Abridged, for Electrical Engineering Students. Relative economies of steam engines, steam turbines and internal combustion engines, boilers, heaters, economizers, condensers, piping, and gas producers. Required in Electrical Engineering courses, second semester, senior year. (6 units)

165. STEAM LABORATORY.—Calibration of instruments, tests on brakes, dynamometers, steam calorimeters and injectors; tests on the steam engine, steam turbine, steam pump and gas engine for efficiency and economy; valve setting; comparison of governors; boiler and plant test. Required in Mechanical Engineering courses, first semester, senior year. (8 units)

166. FUEL AND LUBRICANT LABORATORY.—Tests of lubricants, investigation of friction, fuel and gas analysis and calorimetry.

Required in Mechanical and Electrical Engineering courses, second semester, senior year. (3 units)

168. HEAT POWER ENGINEERING.—Principles of thermodynamics and their applications to steam engines, turbines, and internal combustion engines. Study of power plant apparatus. Required in Civil and Chemical Engineering courses, second semester, senior year. (4 units)

170. MECHANICAL ENGINEERING LABORATORY.—Calibration and tests on special apparatus used in mechanical engineering. Visits to and reports on power and manufacturing plants in Southern California. Investigation of special branches of mechanical engineering. Required in Mechanical Engineering courses, second semester, senior year. (4 units)

171. THERMAL PRIME MOVERS.—Similar to 161, but abridged and adapted to the needs of students in Electrical Engineering. Required in Electrical Engineering courses, first semester, senior year. (5 units)

175. STEAM LABORATORY.—Similar to 165, but abridged and adapted to the needs of students in Electrical Engineering. Required in Electrical Engineering courses, first semester, senior year. (4 units)

[SEE ALSO SUBJECTS 100, 101, 102, 103, 112, 201, 225, 226, 251, 252, 253, 261, 270, 271, 272, AND 273.]

MECHANICAL ENGINEERING EQUIPMENT

The equipment 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 which he will use in his engineering career.

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; apparatus for determining the flow of steam through nozzles and orifices; a Fairbanks-Morse stationary type gas engine, a Kerr four stage steam turbine direct-connected to a Fort Wayne direct current generator; a surface condenser, with accurate provision for weighing the condensed steam and cooling water; a Duplex air pump; several injectors of the Lunkenheimer, Pemberthy and Hancock types, a Westinghouse motor-driven air compressor, a small duplex steam pump, a single cylinder steam pump, two motor-driven centrifugal pumps, scales and weighing tanks, a Schuchardt & Schutte tachometer, an American-Thompson indicator, a Crosby outside-spring combined steam and gas engine indicator, a Crosby indicator reducing wheel, and Crosby continuous indicator drum; a flue gas analysis apparatus, and a planimeter; an exhaust heat calorimeter for gas and oil engine tests; a barrel calorimeter, a separator calorimeter, and a throttling calorimeter, for the determination of the quality of steam, an Ellison universal calorimeter, 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 and separately fired steam superheater. 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.

FUEL AND LUBRICANT 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 Riehlé 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.

LABORATORY SHOP.—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

201. SURVEYING.—A study of the elementary operations employed in making surveys for engineering work, including the use, care and adjustment of instruments, linear measurements, angle measurements, note keeping and field methods. Required in Electrical, Mechanical and Civil Engineering courses, first semester, sophomore year. (7 units)

202. ADVANCED SURVEYING.—A continuation of 201, covering topographic surveys, plane-table surveys, triangulation, cross-section surveys, drafting-room methods and mapping, and the solution of problems. Required in Civil Engineering courses, second semester, sophomore year. (7 units)

[NOTE: Students pursuing 202 will spend a week of the spring recess in camp engaged in field operations of triangulation and topographic surveys.]

205. HIGHWAY ENGINEERING.—A comparison of various types of highway construction; the design, construction and maintenance of roads and pavements; methods of road improvement; financing, contracts and specifications. Required in Civil Engineering courses, first semester, junior year. (3 units)

206. Railway Surveying and Engineering.—The theory of railway location and surveys, problems relating to track layout, curves and earthwork; the study of grade problems, the relation between trainloads and operating expenses; signaling. Required in Civil Engineering courses, second semester, junior year. (11 units)

209. Sewerage and Drainage.—Systems for the collection and disposal of sewage; the design of sanitary and storm sewers; the drainage of land; cost assessments. Required in Civil Engineering courses, first semester, senior year. (6 units)

215. Irrigation and Water Supply.—Dealing with the collection and distribution of water for irrigation, power, and domestic purposes; laws pertaining to irrigation; intakes, storage reservoirs, methods of water purification, local distribution; structures for water control; design, construction and operation of systems. Required in Civil Engineering courses, first semester, senior year. (8 units)

217. Theory of Structures.—Methods used in the analysis of framed structures for the analytical and graphical determination of stresses; the use of influence lines; graphic statics applied to roofs and bridges. Required in Civil Engineering courses, first semester, junior year. (11 units)

218. Theory of Structures.—A continuation of 217 covering the design of structural parts, connections, portals, and bracing; a study of arches, cantilever bridges, and deflections. Required in Civil Engineering courses, second semester, junior year. (8 units)

219. Reinforced Concrete.—The theory of reinforced concrete design, with a study of the applications of this type of construction to various engineering structures. Required in Civil Engineering courses, first semester, senior year. (6 units)

220. MASONRY STRUCTURES.—Theory of design and methods of construction of masonry structures; foundations, dams, retaining walls, and arches. Required in Civil Engineering courses, second semester, senior year. (5 units)

221. STRUCTURAL DESIGN.—The design of a plate girder bridge and a steel frame building or tower. Drafting room practice is followed, as affecting both computations and drawings. Required in Civil Engineering courses, first semester, senior year. (9 units)

222. CIVIL ENGINEERING DESIGN.—Special problems, with computations and drawings, in the design of reinforced concrete structures, water power plants and hydraulic regulating works. Required in Civil Engineering courses, second semester, senior year. (9 units)

225. PUBLIC UTILITIES.—A study of the fundamental principles underlying the design, operation and control of electric light and power systems, gas works, transportation systems, and other public utilities—including engineers' estimates of the capacity per inhabitant, cost per unit, income per capita, percentage of operating expenses, fixed charges, and return on the investment. The questions of appraisal, depreciation, amortization, franchises, contract ordinances and public purchase are treated. Required in Electrical, Mechanical and Civil Engineering and Engineering and Economics courses, first semester, senior year. (2 units)

226. CITY PLANNING.—Intended to cover the recent developments in the science of city building, including street and boulevard layouts, parks and playgrounds, radial and circuit highways, interurban and city transportation, union freight and passenger terminals, land values, administration by commission and city manager. A study of recent plans for garden cities, civic centers, ornamental lighting, underground conduits,

etc., and a comparison of local developments with the best American and European examples. Required in Electrical, Mechanical and Civil Engineering, and Engineering and Economics courses, second semester, senior year. (2 units)

[See also Subjects 100, 101, 102, 143, 150, 160, 251, 252, 262, 270, 271, 272, 273, 525, and 526.]

CIVIL ENGINEERING EQUIPMENT

The equipment used for instruction in civil engineering may be grouped under the following heads: instruments for field and office work; models; and reference material. The selection of the equipment, to which additions are continually being made, is designed to be representative of such instruments and materials, characteristic of good practice, which the student later may be called upon to use.

Field and Office Instruments.—Transits, levels, rods, rangepoles, tapes, etc., in such numbers as to fully equip the students for field exercises. The equipment also includes the instruments necessary for work requiring the use of solar attachments, sextant, plane-table, prismatic compass, aneroid barometer, and a current meter for stream gauging. Planimeters, protractors, special calculating instruments, and beam compasses are used by the students in office work. The students in the design courses are provided with individual drawing tables and drawing boards.

Models.—The department has model bridge trusses of wood, so constructed as to illustrate the behavior of the truss members under strain; model bridge joints, and a collection of structural shapes and construction materials.

Reference Material.—In the designing room of the department there is a filing cabinet containing a number of sets of drawings and plans for bridges, dams, buildings, sewage purification works, irrigation and power plants, railroad maps and profiles illustrating good practice. There are also photographs of typical and notable structures, and a complete set of topographical maps of Southern California.

TESTING MATERIALS LABORATORY.—(Described on page 82.) This laboratory is used in Civil Engineering courses in the investigation of stresses and causes of failure in full sized reinforced concrete beams, and in the general testing of the materials of construction.

HYDRAULICS LABORATORY.—For equipment and description see page 83.

APPLIED MECHANICS AND HYDRAULICS

251. APPLIED MECHANICS.—Analytical treatment of problems involving the action of external forces upon rigid bodies; statics; determination of stresses in simple machines and structures; parallel forces and center of gravity; dynamics of translation and rotation; gyroscopic action, inertia, impact; work and energy; friction and lubrication. Required in all Engineering courses, second semester, sophomore year. (10 units)

252. STRENGTH OF MATERIALS.—A study of the fundamental relations between stress and deformation in elastic materials; strength of beams, columns, flat plates, thin and thick cylinders, hooks and curved pieces, arches and retaining walls; deflection of beams under various loading; properties of the common structural materials. Required in all Engineering courses, first half, first semester, junior year. (6 units)

253. GRAPHIC STATICS AND STRUCTURAL DESIGN.—Graphical solution of problems in mechanics and strength of materials; determination of external moments and reactions in machine and structural members under various systems of loading; effect of moving loads. Also, a short course in the practical application of graphical methods, in the design of steel, timber, and reinforced concrete beams, girders, simple bridge and roof trusses, arches, floor slabs, and foundations. Required in Mechanical and Electrical Engineering courses, first semester, junior year. (4 units)

260. MATERIALS OF CONSTRUCTION.—Lectures and class discussions concerning the production and properties of the ma-

terials most commonly used in the mechanic arts and in engineering construction; forestry, lumbering, and the physical properties of wood; causes of decay, preservation processes; protection against parasites and against fire; manufacture of iron and steels from the ore; various conversion processes for steel, wrought iron, malleable iron, etc.; welding processes; heat treatment of steel; the properties of alloy steels; non ferrous alloys; protection against rust and corrosion; manufacture of Portland cement, and discussion of its properties and proper use; choice of sand and rock in concrete; waterproofing of concrete; other engineering materials and their proper use. Required in all engineering courses, first semester, junior year, in connection with Nos. 261 or 262. (1 unit)

261. Testing Materials Laboratory.—Experimental investigation of the properties of cement and concrete, and the commercial tests of these materials; the testing of sand and rock, and the proper proportions for economic mixtures of concrete; tensile, compressive, bending and torsional tests of metals, timber, and other structural materials; tests of hardness, fragility and endurance; determination of proper factors of safety, especially in relation to repeated and reversed stresses; tests of the magnetic and electrical properties of metals; experimental verification of the formulas derived in the theory of Strength of Materials; calibration of apparatus. Required in Mechanical and Electrical Engineering courses, first semester, junior year. (5 units)

262. Testing Materials Laboratory.—Similar to 261, dealing principally with the materials of construction. Required in Civil and Chemical Engineering courses, first semester, junior year. (3 units)

270. Hydraulics.—Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; hydrodynamics. Required in all Engineering courses, last half, first semester, junior year. (4 units)

271. Hydraulic Motors.—A study of the factors that control the operation, design and efficiency of water wheels,

turbines, hydraulic rams, pumps, hydraulic power transmission, special machinery, hydraulic governors, and auxiliary apparatus. Required in Electrical, Mechanical and Civil Engineering courses, second semester, junior year. (4 units)

272. 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 in Electrical, Mechanical and Civil Engineering courses, first half, second semester, junior year. (3 units)

273. HYDRAULIC MACHINERY LABORATORY.—Tests of water-wheels, turbines, impulse wheels, water motors; centrifugal and other pumps; the hydraulic ram and other hydraulic appliances. Required in Electrical, Mechanical and Civil Engineering courses, last half, second semester, junior year. (3 units)

EQUIPMENT FOR APPLIED MECHANICS AND HYDRAULICS

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.

TESTING 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 150,000-pound Olsen universal testing machine, with automatic and autographic attachments, fitted for tension, compression, and bending tests; a 30,000-pound Riehlé universal testing machine; a 50,000-inch-pound Olsen torsion testing machine, a Landgraf-Turner alternating impact testing machine, a White-Souther endurance machine, a ten spindle

fatigue-testing machine (a recent development by this department), an electro-magnetic fatigue testing machine, a 3000 kilogram Brinnell hardness testing machine, and 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, a 1,000-pound Riehlé automatic cement testing machine, several types of sand and cement sieves, Vicat and Gilmore needles, specific gravity apparatus, microscope, analytical balance, apparatus for accelerated tests on cement, flourmeter, rock crusher, bucking board, briquette moulds, and small tools.

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; an American No. 6 centrifugal pump delivers a large flow of water at low pressure, while a 5x10 Fairbanks-Morse duplex power pump and a 10x8x12 Marsh steam pump provide 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.; pressure gauges and several mercury columns, including a 12-foot column provide for pressure measurements.

For the study of hydraulic machinery there is provided an especially designed Francis inward flow turbine fitted with both movable guide vanes and cylinder gate, and provided with three types of runners for low, normal and high speed; also, a Doble impulse wheel, with glass casing for observation of the jet action, a hydraulic ram, a two-stage centrifulgal pump, and several smaller motor-driven pumps.

CHEMISTRY

Thorough training is provided in the five main divisions of the science: inorganic, analytical, organic, theoretical, and industrial chemistry. Systematic instruction in these subjects is given throughout the chemical courses, and chemical research is carried on during the entire senior year.

It is believed that the education of the chemist will be most effective if he is given a thorough and accurate training in the elements of the science, and in research methods; for this reason the effort of the student is directed largely to the acquirement of this fundamental scientific training instead of being diffused over the purely technical sides of the subject. The graduate should thus be able to apply his scientific knowledge to original investigation, or to the study of chemical problems of a technical nature.

Facilities for research are offered in the various branches of chemistry (see especially page 89). The experience and training obtained through research are the most important results of the student's course in chemistry. The searching and accurate methods used and the quality of self-reliance acquired are invaluable in giving the ability to solve independently the intricate problems sure to be encountered.

301. Iorganic Chemistry.—Lectures, recitations, and laboratory exercises in the general principles of chemistry and the descriptive chemistry of the non-metallic elements. The lectures are fully illustrated by experiments. Much attention is paid to the cultivation in the student of clearness in thinking, accuracy in observation and inference, care in manipulation, and neatness in the recording of his work. Required in all courses, first semester, freshman year. (12 units)

301a. INORGANIC CHEMISTRY.—Planned for those students who do not offer chemistry for entrance or who are for any reason deficient in the subject. The work is parallel to that of 301; but more time is assigned to it in order to give such a grounding in chemical theory and laboratory practice as will enable the student to continue with 302 and 311 in the second semester. Required of students deficient in entrance chemistry, first semester, freshman year. (16 units)

302. INORGANIC CHEMISTRY.—A continuation of 301 or 301a; consists of one experimental lecture or recitation a week throughout the semester. It is devoted to the descriptive chemistry of the metallic elements. Required in all courses, second semester, freshman year. (2 units)

311. QUALITATIVE ANALYSIS.—This is a systematic study in the qualitative analysis of solutions of inorganic substances. Six hours a week are devoted to laboratory practice, and one hour a week to a class-room discussion of the work that is being pursued in the laboratory. Text-book: A. A. Noyes, Qualitative Analysis. Prerequisite: 301 or 301a. Required in all courses, second semester, freshman year. (10 units)

312. QUALITATIVE ANALYSIS.—A laboratory study, accompanied by informal conferences, which supplements the freshman course in the same subject by affording instruction in methods for the separation and detection of certain important elements not considered in that course. It includes also extensive laboratory practice in the complete analysis of solid substances, such as alloys, minerals, and industrial products. Text-book: A. A. Noyes, Qualitative Analysis. Prerequisite: 302 and 311. Required in Chemical Engineering and Chemistry courses, first semester, sophomore year. (11 units)

316. QUANTITATIVE ANALYSIS.—Laboratory practice, supplemented by occasional lectures and by personal conferences. The course furnishes an introduction to the subjects of gravi-

metric and volumetric analysis. Text-book: Talbot, Quantitative Analysis. Prerequisite, 312. Required in Chemical Engineering and Chemistry courses, second semester, sophomore year. (8-11 units)

317-318. QUANTITATIVE ANALYSIS.—A continuation of 316. Prerequisite 316. Prescriptive, both semesters, junior year. (6 units each semester)

321. TECHNICAL ANALYSIS.—A laboratory course desigend to familiarize the student with special analytical apparatus and methods used in industrial chemical operations, both for plant control and research. Prerequisite, 316. Required in Chemical Engineering and Chemistry courses, first semester, senior year. (9 units)

323-324. FOOD ANALYSIS.—Laboratory work and conferences, in which a study is made of the analytical methods employed in determining the purity of food products, and in detecting adulteration. Prerequisites, 316, 352, 354. Prescriptive, both semesters, senior year. (6 units each semester)

327-328. RESEARCH IN ANALYTICAL CHEMISTRY.—Original investigation of problems in analytical chemistry. Prescriptive for qualified students as thesis, both semesters, senior year. (6-18 units each semester)

331-332. THEORETICAL CHEMISTRY.—Conferences and recitations in which the general principles of chemistry are considered from an exact, quantitative standpoint. Includes a study of the pressure-volume relations of gases; of the vapor-pressure, boiling point, and freezing point of solutions; of the molecular and ionic theories; of electric transference and conduction; of the rate and equilibrium of chemical reactions; and of thermochemistry. A large number of problems are assigned to be solved by the student. Prerequisites, 316, 403, 404, 457, 458. Required in Chemical Engineering and Chemistry courses, both

semesters, junior year. (8 units first semester, 9 the second)

333-334. THEORETICAL CHEMISTRY LABORATORY.—Laboratory exercises to accompany 331-332. Required in Chemical Engineering and Chemistry courses, both semesters, junior year. (5 units each semester)

335. THEORETICAL CHEMISTRY.—A continuation of 331-332, dealing chiefly with electrochemistry and thermodynamic chemistry. Required in Chemical Engineering and Chemistry courses, first semester, senior year. (7 units)

336. THEORETICAL CHEMISTRY LABORATORY.—Laboratory exercises to accompany 335. Required in Chemical Engineering and Chemistry courses, first semester, senior year. (2 units)

338. SPECIAL TOPICS IN PHYSICAL CHEMISTRY.—The purpose of this course, which is conducted upon the seminar plan, is to familiarize the student with the present status of some of the more important problems in Chemistry and in Physics. The topic will be varied from year to year; that for 1916-17 is radioactivity. Prescriptive, second semester, junior and senior years. (4 units each semester)

341-342. RESEARCH IN THEORETICAL CHEMISTRY.—Consists of laboratory practice, supplemented by library work and informal conferences. Prescriptive for qualified students as thesis, both semesters, senior year. (6-18 units each semester)

351-352. ORGANIC CHEMISTRY.—Lectures and recitations in which the properties, characteristic reactions and classification of the compounds of carbon are studied. Must accompany 353-354. Required in Chemical Engineering and Chemistry courses, both semesters, junior year. (8 units each semester)

353-354. ORGANIC CHEMISTRY LABORATORY.—Laboratory exercises to accompany 351-352. Preparation and purification of

carbon compounds, and study of their characteristic properties. Required in Chemical Engineering and Chemistry courses both semesters, junior year. (6 units each semester)

355. ORGANIC ANALYSIS.—Laboratory practice in qualitative and ultimate organic analysis. In the former, a study is made of the methods used in detecting and identifying compounds of carbon; in the latter, the methods used in determining the elements quantitatively. Prerequisites, 316 and 351. Prescriptive, second semester, junior year. (4 to 6 units)

357. ORGANIC CHEMISTRY LABORATORY.—Continuation of 354. Practice in the carrying out of difficult syntheses of carbon compounds. For qualified students. Prerequisites, 354 and 355. Prescriptive, first semester, senior year. (3 to 6 units)

359-360. RESEARCH IN ORGANIC CHEMISTRY.—Opportunity is offered to qualified students to pursue research in pure organic chemistry under personal supervision of the professor in charge. Prescriptive for qualified students as thesis, both semesters, senior year. (6-18 units each semester)

362. TECHNOLOGY OF PETROLEUM.—Consists of a discussion of the origin, sources, production, and transportation of petroleum; its chemical composition, studies of the processes and products of the refinery, and the utilization of waste and by-products. The proximity of the important oil fields and refineries of Southern California makes frequent inspection trips a valuable feature of the instruction. Books: Redwood, Holde, Gill, Engler-Hofer, and others. Prescriptive, second semester, senior year. (6 units)

372-373. INDUSTRIAL CHEMISTRY.—A study of the more important industrial chemical processes, from the point of view not only of the chemical reactions, but of the conditions and equipment necessary to carry on these reactions. Required in

Chemical Engineering and Chemistry courses, second semester, junior year and first semester, senior year.
(6 units each semester)

378. CHEMICAL ENGINEERING.—Lectures and laboratory work to bring the student in touch with modern practice and problems involved in efficiently carrying out chemical reactions on a commercial scale. In the laboratory, the basic operations of the chemical industries are duplicated on a scale sufficiently large to familiarize the student with the engineering problems of plant construction and operation. Required in Chemical Engineering courses, second semester, senior year. (10 units)

391-392. RESEARCH REPORTS.—Weekly reports by members of the faculty and by advanced students on recent publications and on the progress of problems under investigation in this laboratory. Prescriptive, both semesters, junior year. Required in Chemical Engineering and Chemistry courses, both semesters, senior year. (1-2 units each semester)

CHEMICAL RESEARCH

An unnamed friend has presented to the College $10,000 for the equipment of a Chemical Research laboratory, and has made provision for a permanent annual income of $10,000 for its maintenance. With these funds there has been established in the new Chemistry Building, described below, a research laboratory of physical chemistry, occupying eight rooms and containing facilities for physico-chemical research of the highest grade. Five individual laboratories and one larger room afford space for fourteen workers. An instrument shop containing a Stark precision bench lathe, with milling machine attachment, a sensitive vertical drill, a tool grinder, and a complete set of mechanician's tools, forms part of the laboratory. Precision balances, a Leeds and Northrup

potentiometer, galvanometers, resistance boxes, a special still for conductivity water, thermostats, and precision apparatus for the measurement of electrolytic conductivity, have been provided.

Dr. Arthur A. Noyes, Professor of Theoretical Chemistry in the Massachusetts Institute of Technology, and Director of the Research Laboratory of Physical Chemistry in that institution, has become Director of Chemical Research at Throop College, dividing his time between the two institutions. Scientific investigations in physical chemistry will be carried on by a staff of research associates and by the professors and instructors of the Chemistry Department. The laboratory is open to qualified graduate students for advanced study and research leading to higher degrees.

A new chemistry building (with a floor space of 18,000 square feet) has just been erected, providing ample room and facilities for instruction and research work in chemistry. It contains a lecture room, a chemical library, two recitation rooms, six offices, store-rooms, a laboratory of inorganic chemistry accommodating one hundred and sixty students, an organic chemistry laboratory accommodating twenty-three students, an analytical laboratory accommodating eighty, a physico-chemical laboratory for twenty men, an organic research laboratory with space for four, a research laboratory of physical chemistry accommodating fourteen workers (as already described), an instrument shop, a storage battery room, a still room, and laboratories of industrial chemistry, chemical engineering, technical analysis, and photo-chemistry. In addition to the general heating and ventilating system, special hood ventilation is provided in all the laboratories, those of inorganic and analytical chemistry having

individual desk hoods. Numerous outlets for water, gas, suction, and compressed air systems are provided, and a system of electrical distribution of direct, alternating, high frequency, and storage battery current has been installed.

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. *See the important announcement on page 6.*

401. MECHANICS, MOLECULAR PHYSICS, AND HEAT.—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 students 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 in all courses, first semester, sophomore year. (8 units)

402. 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 in all courses, first semester, sophomore year. (4 units)

403. SOUND, LIGHT, ELECTRICITY, AND MAGNETISM.—Based upon and forming a continuation of 401; 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 in all courses, second semester, sophomore year. (8 units)

404. 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 in all courses, second semester, sophomore year. (4 units)

405. ELECTRICITY AND MAGNETISM.—A more advanced and detailed treatment of these subjects than is given in 403. Required in Electrical and Mechanical Engineering courses, first semester, junior year. (3 units)

406. ELECTRICAL MEASUREMENTS AND METHODS.—Deals with the theory of various electrical measuring instruments and methods, with especial reference to convenience of use, precision, and possible sources of error. Required in Electrical Engineering courses, first semester, junior year. (2 units)

407. ELECTRICAL MEASUREMENTS—LABORATORY.—Supplementing 406. Required in Electrical Engineering courses, first semester, junior year. (2 units)

410. 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, refrigeration, production, regulation and measurement of high temperatures in kilns and furnaces, calorific efficiency of fuels. Prescriptive, second semester, junior year. (7 units)

412. 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)

PHYSICAL RESEARCH

During the current year a fund of $100,000 has been provided for Physical Research, and Dr. Robert A. Millikan of the University of Chicago has been secured to give several months of his time every year to direct this research, with the co-operation of Dr. Arthur A. Noyes in physical chemistry, and that of Dr. George E. Hale, of the Mt. Wilson Solar Observatory, in astrophysics. This fund will be administered in conference with the National Research Council, of which Dr. Hale is chairman (see page 96). Three fellowships, with an annual income of $1,000 each, have been established in the departments of Physical and Chemical Research. Dr. Millikan began his work during the current school year by giving a series of six lectures, with the following subjects: "Electricity in the Nineteenth Century," "X-Rays and the Birth of the New Physics," "The Electron—Its Isolation and Measurement," "Brownian Movements and Sub-Electrons," "The Structure of the Atom," "The Nature of Radiation." Graduate courses will be arranged for candidates for advanced degrees.

RESEARCH IN AERONAUTICS

Just as this catalogue goes to the press, generous and wise friends of the College have undertaken to provide facilities for research in the science of Aeronautics, with every prospect of the co-operation of the United States Government. A wind tunnel will be immediately built and equipped in the best fashion, and a graduate course will probably be provided for students desiring to specialize in this branch of physics and engineering. A wind tunnel consists of a chamber specially constructed and equipped with air-current producing machinery so as to provide facilities with which small model planes may be observed and tested under conditions equivalent to those that obtain in actual flight. A building 20x25x66 feet houses the wind tunnel proper, 16 square feet in section and some 53 feet in length. Air is drawn through an entrance nozzle and through the square tunnel by a four-blade propeller, driven by a ten horsepower motor. Models under test are mounted in the center of a square trunk on the vertical arm of a balance. The propeller works in a sheet metal cylinder seven feet in diameter. By the use of rheostats the propeller speed can be regulated to hold any wind velocity from four to forty miles an hour, the control being very sensitive. The aerodynamical balance consists of three arms mutually at right angles (representing the axes of co-ordinates in space) about and along which couples and forces are to be measured. The model aeroplane is mounted on the upper end of the vertical arm, which projects through an oil seal in the bottom of the tunnel.

The establishment of this new laboratory at Throop College arose from the suggestion of the National Re-

search Council and the advice of Colonel Squier, Chief of Aviation. This Council, which was formed by the National Academy of Sciences at the request of the President, is securing the co-operation of educational institutions in the study of problems connected with national defense. One of the most important of these is the improvement of aeroplanes along the lines suggested by the National Advisory Committee for Aeronautics.

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 work closely with the professional studies. Students are advised to arrange for additional courses if possible.

451. PLANE TRIGONOMETRY.—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)

452. COMPUTATION.—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 in all courses, first semester, freshman year. (4 units)

453. ADVANCED ALGEBRA.—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 in all courses, first semester, freshman year. (4 units)

454. ANALYTIC GEOMETRY.—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. Solid Analytic Geometry includes a brief discussion of the straight line, plane, and quadratic surfaces. Required in all courses, second semester, freshman year. (9 units)

455. SPHERICAL TRIGONOMETRY.—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 observation, a knowledge of spherical trigonometry is necessary. Required in Civil Engineering courses, second semester, freshman year. (4 units)

456. ELEMENTARY ANALYSIS.—A continuation of 453, designed to present portions of advanced algebra of especial interest in engineering, including work in permutations, combinations, probability, continued fractions, solution of equations, empirical equations, and an introduction to Vector Analysis. Prescriptive, second semester, freshman year. (4 units)

457-458. CALCULUS.—The aim of this study 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 in all courses, both semesters, sophomore year. (8 units each semester)

459. DIFFERENTIAL EQUATIONS.—Especially designed to be helpful in the problems of physics, mechanics, and electrical engineering. Prescriptive, first semester, junior year. (6 units)

460. DIFFERENTIAL EQUATIONS.—A continuation of 459; 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)

461. LEAST SQUARES.—Much weight is given to this subject, 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. Prescriptive, second semester, junior year. (5 units)

463-464. ADVANCED CALCULUS—Planned to extend the knowledge gained from the previous studies 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)

GEOLOGY

The courses in Geology and Mineralogy are arranged to emphasize the application of these subjects to engineering problems, and to furnish that knowledge of the economic value of rocks and other earth resources which will meet the needs of the Civil and Chemical Engineering student.

Especial emphasis is given to the nature, mode of occurrence, and economic importance of those resources of our own state, such as gas, oil, clay, materials of construction, and the metals, and to that knowledge of rocks and stratigraphy necessary for the construction of dams, aqueducts, tunnels, and other engineering works.

525. MINERALOGY.—A study of the elements of crystallography, and of the physical and chemical properties, uses, and determination of the more common minerals. Required in Civil Engineering courses, first semester, senior year. (4 units)

526. GEOLOGY.—A general study, dealing with the composition and structure of the earth; the chemical and mechanical work of the atmosphere; the work of water, both surface and underground; glacial action; volcanoes and earthquakes, with special reference to practical interpretation of these conditions. Required in Civil Engineering courses, second semester, senior year. (4 units)

527. GEOLOGY.—A continuation of 526, treating the nature and ditsribution of geologic resources of industrial importance. Prescriptive, first semester, senior year. (4 units)

ECONOMICS AND HISTORY

The subjects in this group are designed with the twofold purpose of giving the student an insight into fundamental economic principles, and to acquaint him with some of the aspects of the practical operation of business enterprises. They furnish the important connecting link between the technical engineer and the man of affairs. Some of the subjects not strictly technical are a proper part of the equipment of any educated man.

551. General Economics.—The principles of economics governing the production, distribution, and consumption of wealth, with particular reference to some of the important business and social problems of the day. Required in all courses, first semester, junior year. (5 units)

552. Economic History.—This subject is treated concretely by tracing the development of a single world-wide industry from its early beginnings in such a way as to show the influence of economic factors in general history and especially on international relationships. Required in all courses, second semester, junior year. (4 units)

553. Statistics.—Statistical methods with the graphic portrayal of results, together with their application to some concrete problems. Required in the course in Engineering and Economics, first semester, junior year. (2 units)

554. Taxation.—A study of the principles and methods of taxation. Required in the course in Engineering and Economics, second semester, senior year. (2 units)

561. Accounting.—A study of the principles of accounting from the standpoint of the business manager or the engineer. Included in the work are the following topics: Capitalization,

depreciation, bond valuation, financial reports, banking and railroad accounting, together with a limited amount of bookkeeping practice. Required in all courses, except Engineering and Economics, second semester, senior year. (4 units)

563. ACCOUNTING.—Similar to 561, but more extensive in its treatment of the subjects considered. Required in the course in Engineering and Economics, first semester, junior year. (6 units)

564. COST ACCOUNTING.—A study of the methods of determining costs in industrial enterprises; of the means used to find direct cost of material and labor, and of the methods of distributing indirect costs or general or "overhead" expenses. Required in the course in Engineering and Economics, second semester, senior year. (5 units)

565. BANKING.—The economic principles of money and banking, including a survey of the different banking systems in operation in the United States, and of the Federal Reserve Act of 1913. The subject is treated from the point of view of the relations of a business man to the bank, rather than the technical details of banking procedure. Required in the course in Engineering and Economics, second semester, junior year. (4 units)

566. SECURITIES.—A study of securities and investments, including the different kinds of securities: government, railroad, industrial, public utility, etc.; the methods of issuing securities; rates of income; and the effect of supervision by public service commissions. In the work of the subject one of the leading financial journals is read and discussed, to give familiarity with business usage. Required in the course in Engineering and Economics, second semester, junior year. (2 units)

575. BUSINESS LAW.—The principles of law as applied to business affairs, including discussion of such fundamental topics

as the definition of law, its sources, and the distinction between law and equity, and a brief study of the law governing contracts, negotiable instruments, agency, partnership, corporations, and employer's liability. Required in all courses, except Engineering and Economics, first semester, senior year.

(4 units)

576-577. BUSINESS LAW.—Similar in scope to 575, but giving a more extensive treatment of the different subjects considered. Required in the course in Engineering and Economics, second semester, junior year, and first semester, senior year.

(5 units each semester)

581-582. COMMERCIAL ORGANIZATION.—Typical forms of organization, such as individual, partnership, corporation, association, and holding company, for the carrying on of business are investigated and compared. The fundamentals of financial reports, methods of promoting, plans for capitalization, and underwriting of securities, are studied. In the second semester particular attention is paid to marketing, including advertising. Required in the course in Engineering and Economics, both semesters, senior year. (5 units each semester)

583-584. INDUSTRIAL MANAGEMENT.—Methods in use for the conduct of successful business enterprises are studied in their general and particular application. Attention is given to such questions as factory location, building design, routing of work, executive organization, standardization, selection of employees, wage systems, welfare improvements, etc. In connection with the study visits are made to the most illustrative factories, warehouses and stores in the vicinity. Required in the course in Engineering and Economics, both semesters, senior year.

(5 units each semester)

585. TRANSPORTATION.—Special investigations and discussion of railroad rates, service, income, operating expenses, and fixed charges; the effect of competition by land and water transit; the decisions of the Interstate Commerce Commission, and the

policies of State Railroad Commissions; valuations, character and cost of construction and requirements for terminal facilities. Required in the course in Engineering and Economics, first semester, senior year. (4 units)

587. MODERN EUROPE.—The political and economic development of Europe from the Congress of Vienna to the present day. Considerable library work is required, together with the preparation of papers, maps, and briefs upon subjects suggested by the course. Required in all courses, second semester, senior year. (5 units)

588. AMERICAN GOVERNMENT.—A study of the American constitutional system as shown in the working of the Federal, State and local governments. Required of students who do not offer United States History and Government as an admission subject, first semester, sophomore year. (4 units)

589. MUNICIPALITIES.—An examination of the origin, development, and organization of the modern city, and a comparative study of municipal government in Europe and America. Special attention is given to a comparison of the operation of the three characteristic forms of city government in the United States: Federal, Commission, and City Manager. Prescriptive, first semester, junior year. (2 units)

590. EDUCATION.—A study of psychology, ethics, and pedagogical theory, designed for the general benefit of students, and for the special equipment of those who wish to become teachers in the public schools of California. (The California State Board of Education authorizes the College to issue special certificates for high school teaching in various subjects to graduates who have taken, in addition to this work, sufficient practice teaching in the subjects concerned. Facilities for this practice teaching are provided by the College for approved candidates.) Required in all courses, first semester, senior year. (3 units)

THE ENGLISH LANGUAGE AND LITERATURE

The College requires an English course of four years for graduation. 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 subjects 601-602, 604, 607-608, 611-612 and 613-614, 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.

601-602. 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, or in the Prose Selections of Duncan, Beck and Graves, 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 rhetoric are discoverable in the actual practice of freshman writing. In addition to a discussion in class each theme is gone over with the student, in

special conference with the instructor. Required in all courses, both semesters, freshman year. (6 units each semester)

603. ENGLISH LITERATURE FROM CHAUCER TO MILTON.—A historical review of English Literature is begun; 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)

604. ARGUMENTATION AND PUBLIC SPEAKING.—The theory of argument and the practice of speaking. The class will engage in daily discussions of current problems. Required in all courses, second semester, sophomore year. (4 units)

605. THE ROMANTIC PERIOD.—Wordsworth, Coleridge, Keats, Shelley and Byron, and the prose writers Lamb, De Quincey, Coleridge, and Hazlitt. Texts: Long, English Literature; G. K. Chesterton, The Victorian Age in Literature. Required in all courses, first semester, junior year. (4 units)

606. AMERICAN LITERATURE.—A brief examination of poetry and prose. Text: Trent and Erskine, Great Writers of America. Required in all courses, second semester, junior year. (4 units)

607-608. TECHNICAL ENGLISH.—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)

609. 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)

611-612. Special Composition.—Supplementary to 601-602; required of any student at the discretion of the Faculty and of the department of English. Consists entirely of theme writing and consultation; may be continued in each individual case as long as the instructor deems it necessary. Prescriptive.

(3 units each semester)

613-614. Spelling.—Satisfaction of the requirements in this subject involves the student's ability to spell those words, both general and technical, that he is likely to use. Prescriptive.

(3 units each semester)

FRENCH, GERMAN, AND SPANISH

In the work of this department two objects are kept steadily in view: to prepare the student to use the languages in scientific work, practical life, and travel; and to give him general training and culture. A good foundation is provided by a careful study of grammar, and a correct pronunciation is sought for by constant practice in the class room. Most of the class work is carried on in the foreign language itself, and writing from dictation is regularly practiced. Opportunity is given to acquire facility in both conversation and reading.

The advanced courses go more deeply into literature, and aim to give some insight into the character, spirit, and traditions of the peoples represented.

Two years of college work in German, French, or Spanish are required of those who offer any one of these languages for admission[1]; and three years of those who enter without such preparation.

651-652. ELEMENTARY FRENCH I.—Grammar and reading; practice in speaking and writing French; dictations. Care is given to correct pronunciation. Books used: Chardenal's French Grammar, and Bacon's Une Semaine á Paris. Prescriptive, both semesters, freshman year. (7 units each semester)

653-654. 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)

655-656. INTERMEDIATE FRENCH.—Composition and syntax are reviewed. The spoken language is freely used in the class

[1]With the approval of the department, a year of one of the other languages may be substituted for the second college year of the language offered for entrance.

room, with frequent dictation. Translation at sight from representative texts receives stress. The following books are used: Victor Hugo's Les Misérables, and some French scientific reader. Required in all courses if French is offered as an entrance language, both semesters, freshman year.[1]
(7 units each semester)

657-658. ADVANCED FRENCH I.—Plays by Corneille, Racine and Molière. Reading of scientific French continued. Required in all courses if French is offered as an entrance language, both semesters, sophomore year.[1] (7 units each semester)

659-660. 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)

661-662. 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)

671-672. ELEMENTARY GERMAN I.—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)

673-674. ELEMENTARY GERMAN II.—Continuation of grammar and exercises. Storm's Immensee and some simple plays are used. Prescriptive, both semesters, sophomore year.
(7 units each semester)

[1]For languages required in Chemical Engineering and Chemistry courses, see page 56.

675-676. 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, Wait's Scientific German reader. Required in all courses if German is offered as an entrance language, both semesters, freshman year.[1] (7 units each semester)

677-678. ADVANCED GERMAN I.—An introduction to the German literature of the nineteenth century. Novels from the works of Freitag, Sudermann, Hauptmann, and Fulda are used, being supplemented with Müller's Electrische Maschinen. Required in all courses if German is offered as an entrance language, both semesters, sophomore year.[1] (7 units each semester)

679-680. ADVANCED GERMAN II.—A continuation of 678, the work being based upon Keller's Bilder aus der Deutschen Literatur, Rauter's allgemeine chemische Technologie, and Pasdkowski's Lesebuch zur Einführung in die Kenntnis Deutschlands und seines geistigen Lebens. Prescriptive, both semesters, junior year. (5 units each semester)

681-682. ADVANCED GERMAN III.—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)

691-692. ELEMENTARY SPANISH I.—Grammar, reading, conversation, dictations. Reading commenced as soon as the first elements of the grammar are mastered; combination of grammar and reading of modern authors kept up throughout the entire course. Conversation based upon the text is carried on entirely in Spanish. Prescriptive, both semesters, freshman year. (7 units each semester)

[1]For languages required in Chemical Engineering and Chemistry courses, see page 56.

693-694. ELEMENTARY SPANISH II.—Review of grammar, especially of the verbs. An easy novel will serve as basis for Spanish conversation. Special study is made of scientific and technical Spanish, the reader by Cornélius Willcox being used as text. Prescriptive, both semesters, sophomore year.
(7 units each semester)

695-696. INTERMEDIATE SPANISH.—A study of 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 Alvareda, etc. A thorough study of scientific and technical Spanish is made. Spanish newspapers and reviews are read. Required in all courses except Chemical Engineering and Chemistry, if Spanish is offered as an entrance language, both semesters, freshman year. (7 units each semester)

697-698. ADVANCED SPANISH I.—A special study is made of the Spanish dramatists Calderón de la Barca, Lope de Vega, and of the modern playwrights Zorilla, Echegaray, and others. Required in all courses except Chemical Engineering and Chemistry, if Spanish is offered as an entrance language, both semesters, sophomore year. (7 units each semester)

699-700. ADVANCED SPANISH II.—Miguel de Cervantes' Don Quixote is studied. Individual reports on chapters read are made by the students in Spanish. Prescriptive, both semesters, junior year. (5 units each semester)

DRAWING

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.

701. MECHANICAL DRAWING AND DESCRIPTIVE GEOMETRY.—Involves the use of instruments, geometric constructions, orthographic projections, principles of dimensioning and descriptive geometry; including simple problems in lines, planes and solids, illustrated by the solution of practical problems. Lectures and recitations are used when necessary. Required in all courses, first semester, freshman year. (5 units)

[NOTE: Students who have had previous training in mechanical drawing may be excused from the elementary work by showing sufficient evidence of proficiency in the use of the instruments.]

702. MECHANICAL DRAWING AND DESCRIPTIVE GEOMETRY.—A study in intersections and developments of planes and solids, isometric and elements of perspective drawing, shades and shadows. Required in all courses, second semester, freshman year. (6 units)

703. MACHINE DRAWING.—Detail sketching from machines in the shops and laboratories, followed by detail drawing and

tracing. All drawings are made with the understanding that they must be suitable for use in the shop. Required in Civil Engineering courses, first semester, sophomore year. (3 units)

705. MACHINE DRAWING.—Detail sketching of machines in the shops and laboratories, followed by detail drawings, tracing and assemblies. All drawings are made with the understanding that they must be suitable for use in the shop. Prescriptive in Electrical and Mechanical Engineering courses, first semester, sophomore year. (3 units)

706. MACHINE DRAWING.—Detail sketching from machines in the shops and laboratories, followed by detail drawings, tracing and assemblies. Students who have already taken machine drawing 705 are required to do more advanced work in detail sketching and tracing of complicated machines, make layouts of piping, and do general mechanical engineering drawing. Required in Electrical and Mechanical Engineering courses, second semester, sophomore year. (3 units)

721-722. FREEHAND LETTERING.—Practice in the construction of freehand letters adapted to use on working drawings, and the layout of titles. Required in all courses, both semesters, freshman year. (2 units first semester, 1 unit second semester)

723-724-725-726. FREEHAND SKETCHING.—Isometric and perspective sketching of machine parts. Design sketching without the use of models. Prescriptive, both semesters, freshman and sophomore years. (1 unit each semester)

SHOP INSTRUCTION

The chief aim of the shop courses is to familiarize the student with the properties of the materials used in engineering, with the ways in which the various mechanical operations are best performed, and with considerations of cost in time and labor.

741. 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 in all Engineering courses, one semester, freshman year. (4 units)

742. 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, and grinding. Working of steel, hardening, tempering, and refining. Structural and ornamental iron work. Required in all Engineering courses, one semester, freshman year. (4 units)

743. 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 in Electrical and Mechanical Engineering courses, one semester, sophomore year. (4 units)

744. 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 in Electrical and Mechanical Engineering courses, one semester, sophomore year. (4 units)

745. Machine Shop Practice.—An abridged course in forging and machine shop practice for students taking chemistry and chemical engineering. Approximately one-third of the time is devoted to forging, the remainder being spent in the machine shop. Required in Chemistry and Chemical Engineering courses, second semester, freshman year. (4 units)

SHOP EQUIPMENT

The shop equipment formerly owned by the College is now the property of the Pasadena High School; it has been installed in the new High School shop buildings and many additions and improvements have been made. These shops are easily accessible from the campus, and the College has exclusive use of this equipment and the services of the instructors on certain days for College students. The wood working, pattern making, forge and machine shops are all amply equipped to carry on the College work outlined above.

COLLATERAL SUBJECTS

751-752. Engineering Journals.—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 ex-

pected to keep individual abstract files of such articles as promise to be of value for reference in his later professional career. A short paper covering some notable development, or the year's progress in some line of engineering work, is required of every student at the close of each year's course. Required in Engineering courses, both semesters, junior year. (2 units)

753-754. ENGINEERING JOURNALS.—A continuation of 751-752. Required in Engineering courses, both semesters, senior year. (2 units)

771-772. GENERAL PROBLEMS.—A descriptive study of the results which should follow the practical application of scientific principles. Recognizing that the first two years of the undergraduate courses must necessarily be devoted chiefly to the fundamental essentials of mathematics, the natural sciences, and language, it is the function of this branch of instruction to furnish a perspective view of both the past and the future of technical development, in order to show the relation of fundamental training to engineering methods. Recent developments in electrical, mechanical, civil, and chemical engineering are discussed by competent instructors, and, in addition, successful technical men are invited to describe their personal experiences to the class. Lectures on "How to Live" and "Personal Efficiency" are also included. Required in all courses, both semesters, freshman year. (2 units)

MILITARY INSTRUCTION

By direction of the Secretary of War, the Throop College battalion is enrolled as a Senior Division in the Reserve Officers' Training Corps, and Captain Louis R. Ball, U. S. Army, Retired, has been designated as Professor of Military Science and Tactics, or "Commandant." Physical development is a part of the course, and all students engage in daily outdoor exercises under direction of the officer in charge. Freshmen and sopho-

mores, in addition, take three hours weekly in military instruction, as applicable especially to engineers; an advanced course being optional for juniors and seniors. Such graduates of a four-year course as are approved by the Commandant and the President of the College may become officers of the Reserve Corps for a limited period.

This course, while contributing definitely to a prudent "preparedness," is of great value to the students as a preparation for life: providing a sounder physique, giving alertness and quickness of action in emergency, and developing such high moral qualities as self-control and subordination to a common purpose in the unselfish service of society. Required in all courses, freshman and sophomore years. (4 units each semester)

THESIS

800. THESIS.—As noted on page 53, each candidate for a degree must submit a thesis on some subject related to his course, devoting such amount of time as may be necessary to secure the desired result. Required of all candidates for a degree, senior year. (12 to 24 units)

Degrees and Honors, 1916

Degrees Conferred June 5

BACHELOR OF SCIENCE

Robert Norman Allen

Max Howard Carson

Bernard Elton Chamberlain

Jesse William Monroe DuMond

Verdine Ellsworth Farmer

Tom Johnson Harris

Kenneth Whiting Rich

Harold Emerson Shugart

Prizes

TRAVEL SCHOLARSHIPS

Junior Prize

Arthur Stert

Freshman Prize

Frank Russell Capra

CONGER PEACE PRIZE

Gene Bryant Heywood

Roster of Students

Abbreviations: E., Electrical Engineering; M., Mechanical Engineering; C., Civil Engineering; Eng., Engineering, undetermined; Ch., Chemistry; Ch.E., Chemical Engineering; Eng. Ec., Engineering and Economics; G., General Courses.

GRADUATE DEPARTMENT

Name and Home Address	Course	Local Address
MANNING, PAUL DEVRIES A.B. Stanford, 1916 *South Pasadena, California*	Ch.	1505 Ramona Avenue South Pasadena

SENIOR CLASS

ASKENASY, ALEXANDER *Los Angeles, California*	Eng. Ec.	917 W. Fifth Street Los Angeles
BAKER, CLARK EDWARD *Santa Ana, California*	E.	Dormitory Pasadena
BEATTIE, JOSEPH ANDREW *Hollywood, California*	M.	800 S. Mentor Avenue Pasadena
KEMP, ARCHIE REED *Pasadena*	Ch.	381 Franklin Avenue Pasadena
MEYER, HARRY PENDLETON *Pasadena*	E.	181 S. Catalina Avenue Pasadena
MOSHER, EZRA DAVIS *Glendale, California*	M.	Dormitory Pasadena
POOLE, FRED LLOYD *Covina, California*	E.	Dormitory Pasadena
RICHARDS, ROY THOMAS *Tempe, Arizona*	E.	201 N. Michigan Avenue Pasadena
SEARL, SIDNEY RICKEY *Los Angeles, California*	Eng. Ec.	Dormitory Pasadena
SOPP, CLAUDE WELLINGTON *Pasadena*	C.	112 Hammond Street Pasadena

SENIOR CLASS—Continued

Name and Home Address	Course	Local Address
STERT, ARTHUR *Oklahoma City, Oklahoma*	M.	Dormitory Pasadena
YOUTZ, JESSE PAUL *Pasadena*	E.	334 W. Green Street Pasadena

JUNIOR CLASS

ANDREWS, CLARK FLAVEL *Los Angeles, California*	E.	658 W. 21st Street Los Angeles
ANNIN, WILLIAM CLEMENT B.S. Occidental, 1916 *Los Angeles, California*	E.	344 W. Avenue 53 Los Angeles
ARMSTRONG, OLIN LEWIS *Whittier, California*	E.	336 N. Painter Avenue Whittier
BJERKE, CLARENCE MARTIN *Los Angeles, California*	C.	Dormitory Pasadena
BOEKENOOGEN, EARL VANCE *South Pasadena*	E.	1014 Magnolia Avenue South Pasadena
BROADWELL, SAMUEL JONATHAN *Covina, California*	Ch.	Dormitory Pasadena
BURNS, BRUCE *Alhambra, California*	M.	21 S. Almansor Street Alhambra
CARNAHAN, STANLEY CROSSON *Los Angeles, California*	Eng. Ec.	1816 S. Hobart Boulevard Los Angeles
COLES, REGINALD *Los Angeles, California*	M.	933 N. Mariposa Avenue Los Angeles
DOWD, MUNSON JULIUS *Pasadena*	C.	123 Elevado Drive Pasadena
HARRIS, HAROLD ROSS *Los Angeles, California*	M.	623 S. Bonnie Brae Los Angeles

JUNIOR CLASS—Continued

Name and Home Address	Course	Local Address
HARRISON, KENNETH JOSEPH *Eagle Rock, California*	C.	227 Stanley Avenue Eagle Rock
HEYWOOD, GENE BRYANT *Pasadena*	C.	963 Galena Avenue Pasadena
HOGE, EDISON RAWLINGS *Pasadena*	Ch. E.	370 S. Marengo Avenue Pasadena
HUBER, JOHN JOSEPH *Mesa, Arizona*	E.	Dormitory Pasadena
IMLER, EUGENE HENRY *Tropico, California*	M.	Dormitory Pasadena
JOHNSON, WALLACE BAYARD *Colton, California*	E.	Dormitory Pasadena
MCDONALD, GORDON ROY *Pasadena*	E.	85 Glorietta Avenue Pasadena
MENDENHALL, EARL *Los Angeles, California*	E.	3813 Hobart Boulevard Los Angeles
MOORE, PAUL A.B. Whittier, 1916 *Whittier, California*	E.	116 Berkeley Way Whittier
MOSHER, FRANK REID *Glendale, California*	Eng. Ec.	Dormitory Pasadena
NELSON, CLARENCE EMBERT *Farmington, California*	E.	206 N. Chester Avenue Pasadena
NUTT, DONOVAN *Pasadena*	Ch.	185 Marion Avenue Pasadena
OGIER, WALTER WILLIAMS, JR. *Pasadena*	C.	162 Oakland Avenue Pasadena
OVERSTROM, CONRAD *Pasadena*	M.	251 S. Hudson Avenue Pasadena

JUNIOR CLASS—Continued

Name and Home Address	Course	Local Address
PEASE, FRANCIS MAYNARD *Alhambra, California*	E.	907 N. Wilson Avenue Alhambra
PETERMANN, PHILIP J. *Los Angeles, California*	M.	2704 Ellendale Place Los Angeles
PIKE, NOEL ALEXANDER *Los Angeles, California*	E.	410 Lucas Avenue Los Angeles
PROSSER, NORMAN ISBEL *Pasadena*	E.	1101 Charlevoix Street Pasadena
RASMUSSEN, SAMUEL *Selma, California*	C.	Dormitory Pasadena
REYNOLDS, MAYNARD STUCKEY *Alhambra, California*	C.	907 N. Stoneman Avenue Alhambra
RIDENOUR, CARLYLE HOWE *Altadena, California*	M.	Mariposa and Marengo Avenue Altadena
SMITH, ALBERT KNOX, JR. *Los Angeles, California*	E.	3523 Arroyo Seco Avenue Los Angeles
TAYLOR, RALPH TOWER *Pasadena*	M.	966 Elizabeth Street Pasadena
TOWNE, LLOYD ENSIGN *Corona, California*	M.	Dormitory Pasadena
WALKER, EDWARD T. *Los Angeles, California*	C.	4578 Santa Monica Blvd. Los Angeles

SOPHOMORE CLASS

ALTER, RETLA *Long Beach, California*	Ch. E. and E.	Dormitory Pasadena
BARBOUR, CONWAY *Los Angeles, California*	Ch.	1008 W. 28th Street Los Angeles

SOPHOMORE CLASS—Continued

Name and Home Address	Course	Local Address
BARNES MANTON MUHLEMAN *Monrovia, California*	E.	Dormitory Pasadena
BARRAGAR, JOHN JOSEPH, JR. *Santa Monica, California*	E.	17 S. Electric Ave. Pasadena
BARTLETT, HERBERT JARVIS *Pasadena*	C.	R. No. 2, Box 178 Pasadena
BENSINGER, HARROLD JOHNSON *Los Angeles, California*	Ch. E.	145 E. 35th Street Los Angeles
BERCAW, CORLISS ARTHUR *Whittier, California*	Eng. Ec.	426 N. Newlin Avenue Whittier
BEST, VIRGIL HOLMES *Pasadena*	E.	1767 San Pasqual Street Pasadena
BULLARD, HOMER LEE *Glendale, California*	M.	Dormitory Pasadena
CAPRA, FRANK RUSSELL *Sierra Madre, California*	Ch.	Dormitory Pasadena
CASE, HENRY RUGGLES *Pasadena*	Eng.	188 S. Catalina Avenue Pasadena
CHAMBERLAIN, CLARENCE W. *Anaheim, California*	C.	Dormitory Pasadena
CHANDLER, LAWRENCE F. *Glendale, California*	E.	349 W. 5th Street Glendale
CLARK, OLIN JUDSON *El Centro, California*	Ch.	44 Mary Street Pasadena
COWLEY, FRANCIS CRAIG *Seattle, Washington*	E.	San Rafael Heights Pasadena
FLORY, ROBERT WEYBRIGHT *South Haven, Michigan*	Ch.	Reinway 15 Pasadena

SOPHOMORE CLASS—Continued

Name and Home Address	Course	Local Address
HARRIS, MYRON RUSSELL *Pasadena*	Ch.	381 S. Catalina Avenue Pasadena
HARTLEY, JOSEPH FREDERICK *Pasadena*	Ch. E.	509 Jackson Street Pasadena
HAYMOND, WILLIAM H. B. *Riverside, California*	E.	848 E. Colorado Street Pasadena
HIBBARD, CHARLES HENRY, JR. *Pasadena*	E.	156 Bellefontaine Street Pasadena
HOLLINGER, ABRAHAM LINCOLN *Altadena, California*	E.	650 Pine Street Altadena
HOSLER, THOMAS REED *Hollywood, California*	C.	6922 Sunset Boulevard Hollywood
HOUSE, HARVEY WALTER *Los Angeles, California*	Ch. E.	78 Stevenson Avenue Pasadena
JONES, JOHN KENNETH *Los Angeles, California*	Ch.	711 Westlake Avenue Los Angeles
KENDALL, JACKSON WARNER *Pasadena*	Eng. Ec.	210 S. Los Robles Avenue Pasadena
KIRSCHMAN, H. DARWIN *Los Angeles, California*	Eng. Ec.	332 S. Catalina Avenue Pasadena
KNIGHT, ALFRED WHEELOCK *Glendale, California*	Ch.E.	317 E. 2nd Street Glendale
KROUSS, WILLIAM ALFRED *Los Angeles, California*	E.	1401 S. Berendo Street Los Angeles
LAWSON, IVER NORMAN, JR. *San Diego, California*	Eng.	Dormitory Pasadena
LEE, SMITH *Alhambra, California*	M.	603 N. Wilson Avenue Alhambra

SOPHOMORE CLASS—Continued

Name and Home Address	Course	Local Address
LOUD, OLIVER STUART *Sierra Madre, California*	Ch.	417 S. Catalina Avenue Pasadena
LOVE, FRANK MANN *Los Angeles, California*	M.	2212 West Boulevard Los Angeles
MAKOSKY, FRANK CHARLES *Santa Ana, California*	C.	Dormitory Pasadena
MARSHALL, FRED ADELBERT *Pasadena*	Ch.E.	1026 Locust Street Pasadena
OLSON, VERNE LEROY *Los Angeles, California*	Ch. E.	2413 Manitou Avenue Los Angeles
PARMELEE, EDGAR WILSON *Redlands, California*	E.	235 S. Mentor Avenue Pasadena
PAYNE, IVAN LEROY *Santa Barbara, California*	C.	145 S. Catalina Avenue Pasadena
SAUM, DONALD B. *Brookings, South Dakota*	M.	472 Lincoln Avenue Pasadena
SCHERER, PAUL ARMAND *Pasadena*	E.	415 S. El Molino Avenue Pasadena
SHADE, NEVIN R. A.B. Southwestern, 1916 *Caldwell, Kansas*	E.	323 S. Chester Avenue Pasadena
SILVERTHORN, NORTON E. *San Gabriel, California*	E.	San Gabriel
STEELE, JAMES P. *Moneta, California*	Ch. E.	417 S. Catalina Avenue Pasadena
STICHT, ROBERT CARL, JR. *Queenstown, Tasmania, Australia*	Ch. E.	Dormitory Pasadena
TOBIAS, EDWARD L. *Los Angeles, California*	Ch. E.	4614 Milton Place Los Angeles

SOPHOMORE CLASS—Continued

Name and Home Address	Course	Local Address
TORGERSON, TURNER WILLIAM *Pasadena*	E.	1385 N. Mentor Avenue Pasadena
TUTTLE, LYNN BURDETTE *South Pasadena, Californio*	Ch. E.	1410 Hope Street South Pasadena
VAN DEUSEN, EDWARD TIFFANY *Pasadena*	Ch. E.	129 N. Hill Avenue Pasadena
WARD, CLARENCE NORRIS *Los Angeles, California*	M.	621 S. Hope Street Los Angeles
WELDON, WALLACE *South Pasadena, California*	E.	2055 Fletcher Avenue South Pasadena
WHEELOCK, DUDLEY BROOKS *Riverside, California*	C.	Dormitory Pasadena
WOODBURY, ROSCOE ERRETT *Pasadena*	E.	399 S. Los Robles Avenue Pasadena

FRESHMAN CLASS

AMES, PAUL *Los Angeles, California*	Ch. E.	Dormitory Pasadena
ANDERSON, ROBERT *Santa Monica, California*	Eng. Ec.	Dormitory Pasadena
ANDREWS, HORACE C. *Los Angeles, California*	C.	Dormitory Pasadena
ARNOLD, JESSE *Pasadena*	C.	1695 N. Fair Oaks Avenue Pasadena
BARNES, HARTWICK M. *San Diego, California*	C.	Dormitory Pasadena
BARNEWOLT, JOHN *Pasadena*	Ch. Eng.	200 N. Vernon Avenue Pasadena

FRESHMAN CLASS—Continued

Name and Home Address	Course	Local Address
BLACK, JAMES ROBERT *Pasadena*	Eng.	355 N. Euclid Avenue Pasadena
BRITTON, VICTOR G. *Burbank, California*	M.	 Burbank
BROWN, ROY WALTER *Santa Maria, California*	M.	Dormitory Pasadena
BRUCE, ROBERT MANYDIER *Los Angeles, California*	M.	 Altadena
CATLAND, ALFRED *Randsburg, California*	M.	Dormitory Pasadena
CLEMENS, THOMAS BRACKENRIDGE *Los Angeles, California*	M.	1970 La Salle Avenue Los Angeles
CORY, GEORGE LEWIS *Los Angeles, California*	E.	1938 La France Avenue South Pasadena
CRANDELL, LESLIE ARTHUR *Los Angeles, California*	Ch.	628 E. 51st Street Los Angeles
CRANE, HAROLD TRUMAN *Anaheim, California*	Eng. Ec.	355 S. Euclid Avenue Pasadena
CROSBY, PAUL NEWMAN *Hemet, California*	E.	552 Galena Avenue Pasadena
DALBY, ALFRED REGINALD *Los Angeles, California*	C.	1148 Marietta Street Los Angeles
DAVY, LELAND W. *Long Beach, California*	C.	1042 Delmar Street Pasadena
DONAGHOE, ROBERT *Los Angeles, California*	Eng.	1714 Electric Avenue South Pasadena
DUGUID, RUSSELL H. *El Paso, Texas*	E.	Dormitory Pasadena

FRESHMAN CLASS—Continued

Name and Home Address	Course	Local Address
EMERY, PAUL *San Diego, California*	M.	358 S. Euclid Avenue Pasadena
FISHER, FRANK LEROY *Pasadena*	Ch. E.	186 Franklin Avenue Pasadena
FISKE, DONALD B. *Ontario, California*	Ch. E.	Dormitory Pasadena
FRASER, J. HARTLEY *Los Angeles, California*	E.	2807 Elm Street Los Angeles
GRAHAM, SAMUEL LOWRY *Sierra Madre, California*	Ch. Eng.	Sierra Madre
GURLEY, JOHN ADDISON *Alhambra, California*	Eng.	Dormitory Pasadena
HALL, ALBERT DUNBAR *Pasadena*	Ch. Eng.	665 Galena Avenue Pasadena
HERNDON, ARTHUR H. *San Francisco, California*	E.	196 N. Chester Avenue Pasadena
HILL, JAMES *Pasadena*	Ch.	1116 Lura Street Pasadena
HONSAKER, HORTON HOWARD *Pasadena*	E.	628 N. Los Robles Avenue Pasadena
HOUNSELL, E. VICTOR *Los Angeles, California*	E.	842 Waterloo Street Los Angeles
HULL, FARWELL *San Diego, California*	M.	358 S. Euclid Avenue Pasadena
ISHIYAMA, EIITSU *Taisho, Shimonoseki, Japan*	E.	291 S. Marengo Aveune Pasadena
KEITH, WALTER ALLEN *South Pasadena, California*	C.	1015 Fremont Avenue South Pasadena

FRESHMAN CLASS—Continued

Name and Home Address	Course	Local Address
KLEIN, ARTHUR LOUIS *Los Angeles, California*	M.	Dormitory Pasadena
KLING, CLARENCE *Pasadena*	Eng. Ec.	225 S. Hill Avenue Pasadena
KNAPP, ROBERT TALBOT *Los Angeles, California*	M.	1165 Chickopee Street Pasadena
KOLKHORST, EMIL *Orange, California*	M.	Pleasant Street Pasadena
LAVAGNINO, GERALD A. *Pasadena*	Eng.	593 E. California Street Pasadena
LAVENE, CLAYTON CHARLES *Pasadena*	C.	465 N. Marengo Avenue Pasadena
LEVE, MORRIS *Los Angeles, California*	C.	300 Centennial Street Los Angeles
LEWIS, JOHN CLARK *Pacoima, California*	C.	Dormitory Pasadena
LINHOFF, HAROLD R. *Pasadena*	Ch.	417 Winona Avenue Pasadena
LOHMAN, KENNETH ELMO *Los Angeles, California*	E.	4408 Santa Monica Boulevard Los Angeles
LUKENS, HORACE PAWLING *Glendale, California*	Eng.	Dormitory Pasadena
MACDONALD, JOHN ARTHUR *Pasadena*	C.	1090 N. Mentor Avenue Pasadena
MAIER, JOSEPH B. *Glendale, California*	E.	250 N. Adams Street Glendale
MALIN, ARCHIE GARDNER *Montebello, California*	E.	Box 148 Montebello

FRESHMAN CLASS—Continued

Name and Home Address	Course	Local Address
MANINGTON, HENRY A. *Los Angeles, California*	Ch. Eng.	2203 W. 24th Street Los Angeles
MCCONNEL, CECIL LEROY *Alhambra, California*	M.	1202 W. Main Street Alhambra
MITCHELL, HERVEY F. *Owensmouth, California*	M.	Dormitory Pasadena
MITTLEHOLTZ, MILTON ANDREW *Pasadena*	E.	1671 Locust Street Pasadena
MORRISON, LLOYD ELVERTON *Pasadena*	C.	724 N. Marengo Avenue Pasadena
ORR, VERNON *Pomona, California*	E.	Dormitory Pasadena
OTIS, RUSSELL MORLEY *Pasadena*	E.	1081 N. Fair Oaks Avenue Pasadena
PALMER, DONOVAN E. *Upland, California*	Ch. E.	Dormitory Pasadena
POLLOCK, ROBERT *Los Angeles, California*	E.	1041 W. 48th Street Los Angeles
POTTS, CLIFFORD *Santa Ana, California*	E.	Dormitory Pasadena
QUIRMBACH, CHARLES FREDERICK *Needles, California*	Ch. Eng.	Dormitory Pasadena
RENSHAW, WILLIAM C. *Glendale, California*	E.	Dormitory Pasadena
RICHARDSON, EDMUND F. *Los Angeles, California*	Ch. Eng.	Dormitory Pasadena
ROCKAFIELD, ROSCOE ROLLAND *Chino, California*	M.	1129 Division Street Pasadena

FRESHMAN CLASS—Continued

Name and Home Address	Course	Local Address
ROWLEY, ROBERT ELLSWORTH *Sunland, California*	E.	693 S. Los Robles Avenue Pasadena
SAWYER, MARK *Whittier, California*	E.	Dormitory Pasadena
SMITH, DONALD DEWITT *Los Angeles, California*	E.	Dormitory Pasadena
SNELLING, BUFORD EARL *Pasadena*	M.	1168 N. Hill Avenue Pasadena
STANFORD, EVERETT RUSSELL *South Pasadena, California*	Eng.	1106 Windsor Place South Pasadena
STAUFFER, LEO MAYNARD *Pasadena*	E.	155 Harkness Avenue Pasadena
STONE, ALLISON KINCAID *Los Angeles, California*	M.	717 Parkman Avenue Los Angeles
STORY, CHASE STIMSON *Glendale, California*	M.	1720 W. Broadway Glendale
STRAWN, DONALD KARL *Calexico, California*	E.	Dormitory Pasadena
SUMAN, GEORGE O., JR. *Los Angeles, California*	C.	Dormitory Pasadena
TAKASHIMA, NAOCHIRO *Tokyo, Japan*	E.	Dormitory Pasadena
TAYLOR, REA P. *Pasadena*	Eng.	966 Elizabeth Street Pasadena
TAYLOR, ROBERT B. *Ontario, California*	E.	Dormitory Pasadena
THOMPSON, GURDON RUSSELL *Los Angeles, California*	E.	146 N. Ardmore Avenue Los Angeles

FRESHMAN CLASS—Continued

Name and Home Address	Course	Local Address
THOMPSON, VERNON EUGENE *Porterville, California*	E.	Dormitory Pasadena
THORNBURG, SCOTT *Los Angeles, California*	Ch. E.	Dormitory Pasadena
TYSON, HOWELL NEWBOLD *Pasadena*	M.	40 Oakland Avenue Pasadena
VAZQUEZ, NEFTALI ENRIQUE *Azusa, California*	C.	267 State Street Pasadena
VISSCHER, KARL HUGO KRAGHT *Los Angeles, California*	Ch.E.	Dormitory Pasadena
WALKER, ISAAC DALLAS *San Dimas, California*	E.	Dormitory Pasadena
WHITE, PAUL MEACHAM *Oxnard, California*	C.	Dormitory Pasadena
WHITWORTH, GEORGE KELLOG *Sierra Madre, California*	E.	Box 405 Sierra Madre
WHITWORTH, JOHN CURTIS *Pasadena*	M.	Lincoln and Ventura Avenues Pasadena

Roster of College Alumni

NOTE: Throop College of Technology 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 more clearly the aim of the school. "Father Throop" was a pioneer in practical education. By his wise direction polytechnic schools have become a prominent part of the educational equipment of the Pacific coast. For many years this institution 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 thus fostered had become so thoroughly embodied in the state educational system that the Board of Trustees decided to devote their whole energies to the development of the institution as a college of technology. Departments tending to obscure this aim, such as that of the normal arts and the Academy, were relinquished, and a complete reorganization effected. In 1913 the legal name of the corporation became Throop College of Technology.

Following are the College alumni from the beginning:

1896

GEORGE F. DOTY, A. B.....*611 Santa Monica Boulevard*
Santa Monica, California
Manager Provident Pledge Corporation.

DIANTHA M. HAYNES, A. B.....*310 North Francisca Avenue*
Redondo Beach, California
[A.B., Leland Stanford Junior University, 1905.]
Instructor in Science, Redondo High School.

1897

JOSEPH GRINNELL, A.B.....*2543 Durant Avenue*
Berkeley, California

[A.M., Leland Stanford Junior University, 1901; Ph.D., 1913.]

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

ROY BEEDE BLACKMAN, A.B.....*Dagupan, Pangasinan*
Philippine Islands

Assistant Engineer, Bureau of Public Works. Publication: "Woodworking, A Manual of Elementary Carpentry for Philippine Schools."

FRANK BALDWIN JEWETT, A.B.....*463 West Street*
New York City

[Ph.D., University of Chicago, 1902.]

Chief Engineer, Western Electric Company. Director of American Institute of Electrical Engineers. 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; "Long Distance Telephony in America," International Electrical Congress, Turin, Italy, 1911; "Some Recent Developments in Telephony and Telegraphy," Second Pan-American Scientific Congress, 1916.

1900

IRVING CHESTER HARRIS, A.B.....*802 Federal Building*
Chicago, Illinois

Engineer in charge of Inspection of Materials,
United States Reclamation Service.

ALBERT OLSON, A.B.....*Deceased*

1901

LEONARD E. DAVIDSON, B.S.....*3020 Deakin Street*
Berkeley, California
Instructor in Manual Training,
San Francisco City Schools.

1902

KIRK WORRELL DYER, B.S.....*Cromwell, Connecticut*
[S.B., Massachusetts Institute of Technology, 1907.]
Secretary-Treasurer Frisbie Motor Co.
Trustee Norwich State Insane Asylum.

JAMES MASON GAYLORD, B.S.....*412 Tramway Boulevard*
Denver, Colorado
[S.B., Massachusetts Institute of Technology, 1907.]
Engineer, United States Reclamation Service.

MAUDE LOUISE NICHOLSON, B.S.....*1041 North Hudson Avenue*
Pasadena, California

1903

RICHARD WOOLSEY SHOEMAKER, B.S.....*1127 Merchants' National Bank Building, Los Angeles, California*[1]
Electrical Engineer.

1904

JAMES LOUIS BEARDSLEY, B.S.....*Deceased*

HENRY CHESTER MCCUTCHAN, B.S.....*1022 Santa Fe Avenue*
Los Angeles, California
With Holabird-Reynolds Electric Company.

1906

JOHN CLARENCE GAYLORD, B.S.....*1025 Montrose Avenue*
South Pasadena, California
[S.B., Massachusetts Institute of Technology, 1908.]
Engineering Department, Southern California Edison Co.

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[1]Latest available information (1915).

EDGAR SCHUYLER MAXSON, B.S.....*Capiz, Capiz Province, Philippine Islands*
Principal, Trade School.

FRANK EDWARD NORTON, B.S.....*Garfield, Utah*[1]
With Utah Copper Company.

HILDA WOOD, B.S. (MRS. JOSEPH GRINNELL).....*2543 Durant Avenue, Berkeley, California*
[M.S., University of California, 1913.]

Publications: (With Joseph Grinnell) "Reptiles of Los Angeles County, California" (Throop Institute Bulletin No. 35). "Bats of California."

1907

JAMES COLLINS MILLER, B.S.....*Edmonton, Alberta, Canada*
[A.M., Columbia University, 1910; Ph.D., 1912.]
Director of Technical Education, Province of Alberta. Publication: "Rural Schools in Canada."

RAFAEL PIMENTEL, JR., B.S.....*4 Calle de Danceles No. 96 Mexico City, Mexico*
Engineer, Water Supply and Drainage Project, San Salvador, Central America. Deputy to the Congress of Oaxaca.

NEW FOUNDATION

1911

HAROLD CURTIS HILL, B.S.....*24 Baker Street West Lynn, Massachusetts*
Engineer, Small Motor Sales Department, General Electric Company.

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[1]Latest available information (1911).

STANLEY MORTON LEWIS, B.S.....*903 West Washington Street, Fort Wayne, Indiana*
Test Department, General Electric Company.

ROYAL VINCENT WARD, B.S.....*West Tenth Street Upland, California*
Ranchman.

1912

BENJAMIN FERGUSON, B.S.....*1546 West Adams Street Phoenix, Arizona*
Engineer, Arizona Corporation Commission.

NORMAN EGBERT HUMPHREY, B.S.....*131 North Euclid Avenue Pasadena, California*
Municipal Light Department, Pasadena.

JOHN DODGE MERRIFIELD, B.S.....*62 Holmes Road Pittsfield, Massachusetts*
Foreman, Motor Test,
General Electric Company.

FRANK CURT MILLER, B.S.....*City Hall Burbank, California*
Manager, Light, Power and Water Department,
Burbank, California.

1913

RAY GERHART, B.S.....*Phoenix, Arizona*
Sales Department, International Steam Pump Company.

CHESTER RAYMOND HOVEY, B.S.....*817 Monterey Road South Pasadena, California*
Chief Draftsman, Department of Highways,
Los Angeles County.

LOUIS JACOB KOCH, JR., B.S.....*308 North Soto Street*
Los Angeles, California
Estimator, Thomas Haverty Co., Heating, Ventilating and Plumbing Contractors.

RALPH WILLARD PARKINSON, B.S.....*Maracaibo, Venezuela*
Engineer, Maracaibo Electric Light Company.

HERBERT SIDNEY WOOD, B.S.....*Clarkdale, Arizona*
Electrician with United Verde Copper Company.

1914

WILLIAM FINLAW AYARS, B.S.....*6 Oak Street*
Salem, New Jersey
Treasurer, Ayars Machine Company.

EVERETT SOUTHWORTH GARDINER, B.S.....*1051 South Alvarado St.*
Los Angeles, California
College of Law, University of Southern California.

HENRY BERNHARDT GERCKENS, B.S.....*140 West Thirty-Ninth Street, Los Angeles, California*
Draftsman.

VIRGIL FRANKLIN MORSE, B.S.....*385 South Chester Avenue*
Pasadena, California
In charge of Industrial Department,
Los Angeles Public Library.

WALTER LAMB NEWTON, B.S.....*832 San Fernando Building*
Los Angeles, California
Engineer with George A. Damon, Consulting Engineer. Publication: (with Royal W. Sorensen) "Inherent Voltage Relations in Y and Delta Connections"—Proceedings American Institute of Electrical Engineers, 1914. (Throop College Bulletin, No. 64.)

ALBERT WILLIAM WELLS, B.S.....*160 Lafayette Street*
Schenectady, New York
Designing Engineer Railway Locomotive Department,
General Electric Company.

GUY DEWITT YOUNG, B.S.....*Gardena, California*
With Los Angeles Gas & Electric Corporation.

1915

HAROLD AISWORTH BLACK, B.S.....*32 North Grand Oaks Avenue*
Pasadena, California
With O. K. Acetylene Company.

ROBERT ARNOLD WILLIAM BULTMANN, B.S.....*149 East Avenue*
Monrovia, California
Chief Draftsman, American Products Company,
Pasadena.

EARL ANDREWS BURT, B.S.....*795 Santa Barbara Street*
Pasadena, California
Assistant Highway Engineer, County Road Department.

RAYMOND FULLER CALL, B.S.....*1622 Santa Clara Street*
Ventura, California
Instructor, Ventura Union High School.

RAYMOND OSGOOD CATLAND, B.S.....*Santa Ana, California*
Draftsman, Griffith Machine Works, Los Angeles.

VERNE DONALD ELLIOTT, B.S.....*21 Bower's Court*
Pasadena, California
With Pacific Light and Power Co.

ROBERT SINDORF FERGUSON, B.S.....*1640 North Fair Oaks Avenue*
Pasadena, California
Instructor, Throop College of Technology.

WILLIAM MOWRY HOLMES, B.S.....*917 North Wilson Avenue*
Alhambra, California
With Pacific Light and Power Corporation.

HERBERT BRAYTON HOLT, B.S.....*747 Kerckhoff Annex*
Los Angeles, California
With Engineering Department,
Atchison, Topeka and Santa Fe Railway.

CHARLES HERBERT WILCOX, B.S.....*601 Chapel Street*
Schenectady, New York
Student-Engineer, General Electric Company.

1916

ROBERT NORMAN ALLEN, B.S.....*2139 Canyon Drive, Hollywood,*
Los Angeles, California
Hydraulic Engineering Department,
Pacific Light and Power Corporation,

MAX HOWARD CARSON, B.S.....*1699 East Walnut Street*
Pasadena, California
Surveyor, Transmission Department, Pacific Light and
Power Corporation.

BERNARD ELTON CHAMBERLAIN, B.S.....*56 Elgin Park*
San Francisco, California
With Engineering Department, Atchison, Topeka, and
Santa Fe Railway.

JESSE WILLIAM MONROE DUMOND.....*902 Campbell Avenue*
Schenectady, New York
Student-Engineer, General Electric Company.

VERDINE ELLSWORTH FARMER.....*785 State Street*
Schenectady, New York
Student-Engineer, General Electric Company.

TOM JOHNSON HARRIS.....*138 North Hill Street*
Los Angeles, California
With Commercial Engineering Department,
Pacific Telephone and Telegraph Company.

KENNETH WHITING RICH.....*Nordhoff, California*
Instructor, Nordhoff High School.

HAROLD EMERSON SHUGART.....*144 South Gramercy Place*
Los Angeles, California
With United States Reclamation Service.

Index

THROOP COLLEGE OF TECHNOLOGY

COURSES IN ELECTRICAL MECHANICAL AND CIVIL ENGINEERING, CHEMISTRY, CHEMICAL ENGINEERING, ENGINEERING AND ECONOMICS, AND GRADUATE COURSES

PASADENA, CALIFORNIA