

NUMBER 140

personal copy

150

BULLETIN

OF THE

CALIFORNIA INSTITUTE

OF

TECHNOLOGY

A COLLEGE, GRADUATE SCHOOL, AND INSTITUTE OF RESEARCH IN SCIENCE, ENGINEERING AND THE HUMANITIES

CATALOGUE NUMBER

FOR

1936

PUBLISHED BY THE INSTITUTE JANUARY, 1936 VOLUME XLIV

NUMBER 149

BULLETIN

OF THE

CALIFORNIA INSTITUTE

OF

TECHNOLOGY

A College, Graduate School, and Institute of Research in Science, Engineering, and the Humanities

CATALOGUE NUMBER

PASADENA, CALIFORNIA

JANUARY, 1936

Contents

	PAGE
ACADEMIC CALENDAR	. 5
Officers:	
The Board of Trustees	6
Officers of the Board of Trustees	6
Administrative Officers of the Institute	. 0 7
Advisory Council	
Officers and Committees of the Faculty	
STAFE OF INSTRUCTION AND BESEARCH	. 0
STAFF OF INSTRUCTION AND RESEARCH SUMMARY	. 47
CALIFORNIA INSTITUTE ASSOCIATES	50
EDUCATIONAL POLICIES	. 61
EDUCATIONAL BUILDINGS AND FACILITIES	. 01 64
ATHEN FIN	74
STUDENT HOUSES	75
EXTRA-CUBRICULAR OPPORTUNITIES	. 76
STUDENT HEALTH AND PHYSICAL EDUCATION	77
REQUIREMENTS FOR ADMISSION TO UNDERGRADUATE STANDING	80
Expenses	86
REGISTRATION AND GENERAL REGULATIONS	90
SCHOLASTIC GRADING AND REQUIREMENTS	91
SCHOLARSHIPS AND PRIZES	. 96
STUDY AND RESEARCH AT THE CALIFORNIA INSTITUTE:	
Physics	. 98
Mathematics	. 99
Chemistry and Chemical Engineering	99
Engineering	101
Aeronautics	104
Geological Sciences	107
Biological Sciences	110
Astrophysics	111
The Humanities	114
INFORMATION AND REGULATIONS FOR GRADUATE STUDENTS	117
DESCRIPTION OF UNDERGRADUATE AND FIFTH-YEAR COURSES	137
Schedules of Undergraduate Courses	140
SCHEDULES OF COURSES FOR THE DEGREE OF MASTER OF SCIENCE	155
SUBJECTS OF INSTRUCTION	159
Degrees and Honors, 1935.	240
GRADUATE STUDENTS	247
UNDERGRADUATE STUDENTS	255
INDEX	269

	1936									1937																	
JANUARY									J	υL	Y			JANUARY								JULY					
S	A	Î]I	' W	T	$ \mathbf{F} $	s	$\mathbf{\bar{s}}$	м	T	W	Т	$ \mathbf{F} $	s	S	M	T	W	$ \mathbf{T} $	F	s	s	M	Т	W	Т	Ī	
12 12 19 26	122	3 3 1 2 7 2	1 7 8 4 18 1 22 3 29	2 3 9 5 16 2 23 30	$ \begin{array}{r} 3 \\ 10 \\ 17 \\ 24 \\ 31 \\ $	4 11 18 25 	 5 12 19 26		$ \begin{array}{c} 7 \\ 7 \\ 14 \\ 21 \\ 28 \\ \end{array} $	$ \begin{array}{c} 1 \\ 8 \\ 15 \\ 22 \\ 29 \\ \end{array} $	2 9 16 23 30	3 10 17 24 31	4 11 18 25 		$ \begin{array}{c} $	5 12 19 26	 6 13 20 27 	$ \begin{array}{c} 7 \\ 7 \\ 14 \\ 21 \\ 28 \\ \end{array} $	1 8 15 22 29	2 9 16 23 30	 4 11 18 25	 5 12 19 26 	6 13 20 27	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ $	$ \begin{array}{c} 1 \\ 8 \\ 15 \\ 22 \\ 29 \\ \end{array} $		
-	I	EP	R	JAI	RY		AUGUST					FEBRUARY						AUGUST									
s	N	1 I	W	T	F	s	S	м	T	W	T	F	S	s	M	T	Ŵ	Т	F	S	S	M	Т	W	т	Ī	
· · 2 9 16 23	$\frac{1}{1}$	3 0 1 7 1 4 2	4 1 12 3 19 5 20	5 6 2 13 2 20 5 27	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ \end{array} $	1 8 15 22 29	$ \begin{array}{c} 2 \\ 9 \\ 16 \\ 23 \\ 30 \end{array} $	$3 \\ 10 \\ 17 \\ 24 \\ 31$	$ \begin{array}{c} \\ 4 \\ $	$ \begin{array}{c} 5 \\ 12 \\ 19 \\ 26 \\ \end{array} $	$ \begin{array}{c} 6 \\ 13 \\ 20 \\ 27 \\ \\ $	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ \end{array} $	1 8 15 22 29	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ $	1 8 15 22 	2 9 16 23 	$ \begin{array}{c} 3 \\ 10 \\ 17 \\ 24 \\ \\ \\ $	4 11 18 25 	5 12 19 26	6 13 20 27 	$ \begin{array}{c} 1 \\ 8 \\ 15 \\ 22 \\ 29 \\ \end{array} $	2 9 16 23 30	$ \begin{array}{r} 3 \\ 10 \\ 17 \\ 24 \\ 31 \\ \end{array} $	$ \begin{array}{c} 4 \\ 11 \\ 18 \\ 25 \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ \dots \\ $	5 12 19 26		
Γ		M	AR	CI	r		SEPTEMBER						MARCH						SEPTEMBE								
S	<u>I</u> N	ΪĮΊ	' W	T	F	S	S	Μ	Т	W	T	F	s	s	M	T	W	Т	F	S	s	М	Т	W	Т	Ī	
1 15 22 29	123	$2 \\ 3 \\ 1 \\ 6 \\ 1' \\ 3 \\ 2 \\ 0 \\ 3 \\ . $	$\begin{array}{c} 3 & 4 \\ 0 & 11 \\ 7 & 12 \\ 1 & 24 \\ 1 & 24 \\ 1 & 1 \\ 1 &$	12 12 19 26	6 13 20 27	7 14 21 28	$ \begin{array}{c} 6 \\ 13 \\ 20 \\ 27 \\ . $	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ \dots \end{array} $	$1 \\ 8 \\ 15 \\ 22 \\ 29 \\$	$2 \\ 9 \\ 16 \\ 23 \\ 30 \\$	3 10 17 24	4 11 18 25	$5 \\ 12 \\ 19 \\ 26 \\$	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ $	$1 \\ 8 \\ 15 \\ 22 \\ 29 \\$	2 9 16 23 30	3 10 17 24 31	4 11 18 25 	5 12 19 26 	$ \begin{array}{c} 6 \\ 13 \\ 20 \\ 27 \\ \cdot \cdot \\ \end{array} $	5 12 19 26	6 13 20 27	$^{}_{7}$ 14 21 28 	1 8 15 22 29	2 9 16 23 30		
		A	PR	IL				C	C	ro:	BE	R		APRIL						OCTOBER							
s	M	I T	W	T	F	S	s	M	T	W	Т	F	s	S	M	T	Ŵ	T	F	S	S	M	Т	W	Т	ĺ	
$12 \\ 19 \\ 26 \\$	1 2 2	5 14 3 14 7 28	1 12 1 12 1 22 3 29	1 2 9 16 23 30	$ \begin{array}{c} 3 \\ 10 \\ 17 \\ 24 \\ \cdot \cdot \\ \end{array} $	4 11 18 25	$^{}_{4}$ 11 18 25 	· · · 12 19 26	6 13 20 27	7 14 21 28	1 8 15 22 29	2 9 16 23 30	3 10 17 24 31	 4 11 18 25	· · · 12 19 26 · · ·	$ \begin{array}{c} 6 \\ 13 \\ 20 \\ 27 \\ $	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ $	1 8 15 22 29	2 9 16 23 30	$3 \\ 10 \\ 17 \\ 24 \\ \\$	$ \begin{array}{r} 3 \\ 10 \\ 17 \\ 24 \\ 31 \end{array} $	$^{-4}_{11}$ 11 18 25 	$ \begin{array}{r} 5 \\ 12 \\ 19 \\ 26 \\ \end{array} $		$\frac{1}{21}$		
		3	VI A	Y			NOVEMBER						MAY						NOVEMBER								
S]N	r 1	W	Т	F	s	S	M	т	W	Т	F	s	S	М	Т	W	Т	F	s	s	M	Т	W	т		
$3 \\ 10 \\ 17 \\ 24 \\ 31$	1 2		6 13 20 27	$ \begin{array}{c} 7 \\ 7 \\ $	$ \begin{array}{c} 1 \\ 8 \\ 15 \\ 22 \\ 29 \\ \end{array} $	2 9 16 23 30	$ \begin{array}{c} 1 \\ 8 \\ 15 \\ 22 \\ 29 \\ \cdot \cdot \end{array} $	`2 9 16 23 30	$ \begin{array}{r} 3 \\ 10 \\ 17 \\ 24 \\ \\ \\ $	4 11 18 25 	$5\\12\\19\\26\\$	6 13 20 27 	$7 \\ 14 \\ 21 \\ 28 \\ \\$	2 9 16 23 30	$3 \\ 10 \\ 17 \\ 24 \\ 31$	4 11 18 25	5 12 19 26	$^{+}_{-6}$ 13 20 27 	$\frac{7}{14}$ 21 28	$1 \\ 15 \\ 22 \\ 29 \\$	$ \begin{array}{c} 7 \\ 7 \\ $	$1 \\ 8 \\ 15 \\ 22 \\ 29 \\$	2 9 16 23 30	3 10 17 24 	$4 \\ 11 \\ 18 \\ 25 \\ \\$	1144	
JUNE				<u> </u>	DI	ECI	EM	BI	R				J	UN	E				DI	EC)	EM	BE	1				
s	$ ^{\mathbb{N}}$		- W	T	F	<u>s</u>	s	M	$\begin{bmatrix} T \\ - \end{bmatrix}$	<u></u>	\mathbf{T}	$ - \mathbf{F} $	S		M	Т	W	<u>T</u>	F	s	S	M 	T	<u>W</u>			
.7 14 21 28	1 22 29		$3 \\ 10 \\ 17 \\ 24$	$ \begin{array}{c} 4 \\ 11 \\ 18 \\ 25 \\ \end{array} $	$5\\12\\19\\26$	$ \begin{array}{c} 6 \\ 13 \\ 20 \\ 27 \\ 27 \\ \end{array} $		$7 \\ 14 \\ 21 \\ 28$	1 8 15 22 29	$ \begin{array}{c} 2 \\ 9 \\ 16 \\ 23 \\ 30 \end{array} $	$ \begin{array}{r} 3 \\ 10 \\ 17 \\ 24 \\ 31 \end{array} $	$\begin{array}{c} 4 \\ 11 \\ 18 \\ 25 \end{array}$	$5 \\ 12 \\ 19 \\ 26$	$6\\13\\20\\27$	$^{++}_{21}^{+++}_{-28}^{++++}$	1 8 15 22 29	$ \begin{array}{c} 2 \\ 9 \\ 16 \\ 23 \\ 30 \\ \end{array} $	$3 \\ 10 \\ 17 \\ 24$	$4\\11\\18\\25$	$5\\12\\19\\26$	5 12 19 26	$^{+++}_{-+++}$	$ \begin{array}{c} 7 \\ 14 \\ 21 \\ 28 \\ \end{array} $	$ \begin{array}{c} 1 \\ 8 \\ 15 \\ 22 \\ 29 \\ 29 \\ \end{array} $	$2\\9\\16\\23\\30$	1122	

Calendar

1936

JANUARY 2.	Registration (9 A. M. to 3 P. M.)
JANUARY 18	Examinations for Removal of Conditions
MARCH 1I	ast Day for Applications for Fellowships and Assistantships.
MARCH 16-23	1
Максн 20	Notifications of Award of Fellowships and Assistantships
Максн 21	
Максн 22-2	9Recess
Максн 28	
Макси З	
April 11	
April 18	List of Approved Candidates for Bachelor of Science. Degree Posted
April 25 an	d MAY 2Examinations for Admission to Freshman Class
	and for Freshman Scholarships (see Page 81)
MAY 28	Last Day for Examinations and Presenting Theses for the
	Degree of Doctor of Philosophy
MAY 30	
JUNE 6	
	Bachelor of Science and Master of Science
JUNE 8-13	Term Examinations for all Undergraduates except Seniors
JUNE 9	
	Course in Science (10 A. M.)
JUNE 10	
JUNE 11	Class Day
00MH 11	Class Day
JUNE 12	Commencement
JUNE 12 JUNE 12	
JUNE 12 JUNE 12 JUNE 11-13	
JUNE 12 JUNE 12 JUNE 11-13 JUNE 13	Commencement Annual Meeting of Alumni Association Examinations for Admission to Upper Classes End of College Year (12 M.)
JUNE 12 JUNE 12 JUNE 11-13 JUNE 13 JUNE 22	Commencement Annual Meeting of Alumni Association Examinations for Admission to Upper Classes End of College Year (12 M.) Meeting of Freshman Registration Committee
JUNE 12 JUNE 12 JUNE 11-13 JUNE 13 JUNE 22 JUNE 23	Class Day <u>Commencement</u> Annual Meeting of Alumni Association Examinations for Admission to Upper Classes End of College Year (12 M.) Meeting of Freshman Registration Committee Meeting of Registration Committee
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1	
JUNE 12 JUNE 12 JUNE 13 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1	
JUNE 12 JUNE 12 JUNE 12 JUNE 11-13 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1	Commencement
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 1	Commencement
JUNE 12 JUNE 12 JUNE 11-13 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2	Class Day <u>Commencement</u> <u>Annual Meeting of Alumni Association</u> <u>Examinations for Admission to Upper Classes</u> <u>End of College Year (12 M.)</u> <u>Meeting of Freshman Registration Committee</u> <u>Meeting of Registration Committee</u> 1 and 12Examinations for Admission to Freshman Class (see Page 81) 8 and 19Examinations for Admission to Upper Classes <u>Examinations for Removal of Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditi</u>
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2	Commencement
JUNE 12 JUNE 12 JUNE 13 JUNE 13 JUNE 22 JUNE 22 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2.	Commencement
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 23 JUNE 23 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2	Commencement
JUNE 12 JUNE 12 JUNE 13 JUNE 13 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2	Class Day Commencement
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 NOVEMBER 26	
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 22 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. NOVEMBER 26 DECEMBER 1.	Commencement
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 22 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. NOVEMBER 26 DECEMBER 1 DECEMBER 1 DECEMBER 1	Conservation of the second secon
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 24 NOVEMBER 26 DECEMBER 1. DECEMBER 17	Class Day <u>Commencement</u> <u>Commencement</u> <u>Annual Meeting of Alumni Association Examinations for Admission to Upper Classes <u>End of College Year (12 M.)</u> <u>Meeting of Freshman Registration Committee</u> <u>Meeting of Registration Committee</u> Meeting of Registration Committee 1 and 12Examinations for Admission to Freshman Class (see Page 81) 8 and 19Examinations for Admission to Upper Classes <u>Examinations for Removal of Conditions</u> <u>Conditions</u> <u>Examinations for Removal of Conditions</u> <u>Conditions</u> <u>Beginning of Instruction</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Conditions</u> <u>Examinations (9 A. M. to 3 P. M.)</u> <u>Examinations (9 A. M. to 3 P. M.)</u> <u>Examinations (9 A. M. to 3 P. M.)</u> <u>Beginning of Instruction</u> <u>Conditions</u> </u>
JUNE 12 JUNE 12 JUNE 13 JUNE 13 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 NOVEMBER 2 NOVEMBER 1 DECEMBER 11 DECEMBER 17	Class Day Commencement Commencement Annual Meeting of Alumni Association Examinations for Admission to Upper Classes End of College Year (12 M.) Meeting of Freshman Registration Committee Meeting of Registration Committee Meeting of Registration Committee and 12Keting of Admission to Freshman Class (see Page 81) 8 and 19Keting of Admission to Upper Classes SKeting of Admission to Upper Classes (see Page 81) 8 and 19Keting of Admission to Upper Classes SKeting of Admission to Upper Classes (see Page 81) 8 and 19Keting of Admission to Upper Classes SKeting of Admission to Upper Classes (see Page 81) 9 and 19Keting of Admission of Freshmen (9 A. M.) 4-25Registration of Students Transferring from other Colleges (9 A. M. to 3 P. M.) 5General Registration (9 A. M. to 3 P. M.) 8Beginning of Instruction 29Thanksgiving Recess Last Day for Announcing Candidacy for Bachelor's Degree e-17Term Examinations Fund of Fived Torm (5 R. M.)
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 SEPTEMBER 2 NOVEMBER 26 DECEMBER 11 DECEMBER 17 DECEMBER 17	Class Day Commencement Commencement Commencement Commencement Commencement Commencement Examinations for Admission to Upper Classes End of College Year (12 M.) Meeting of Freshman Registration Committee Meeting of Registration of Freshman Class (see Page 81) S and 19Examinations for Admission to Upper Classes S
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. NOVEMBER 26 DECEMBER 17 DECEMBER 17 DECEMBER 17 DECEMBER 17 DECEMBER 17	Conservation of the provided formula of the provi
JUNE 12 JUNE 12 JUNE 12 JUNE 13 JUNE 13 JUNE 22 JUNE 22 JUNE 23 SEPTEMBER 1 SEPTEMBER 1 SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. SEPTEMBER 2. NOVEMBER 26 DECEMBER 1. DECEMBER 1.	Conservation of the constraint of the const

The Board of Trustees

(Arranged in the order of seniority	of service)
HIRAM W. WADSWORTH	Pasadena
ARTHUR H. FLEMING.	Pasadena
GEORGE E. HALE	South Pasadena
HENRY M. ROBINSON	Pasadena
HARRY CHANDLER	Los Angeles
HENRY W. O'MELVENY	Los Angeles
Allan C. Balch	Los Angeles
LOUIS D. RICKETTS	Pasadena
WILLIAM L. HONNOLD	Los Angeles
HARRY J. BAUER	San Marino
BEN R. MEYER	Los Angeles
HARVEY S. MUDD	Beverly Hills
James R. Page	Los Angeles
George E. Farrand	Los Angeles
WILLIAM C. MCDUFFIE	
MAX FARRAND	
JOHN S. CRAVENS	Pasadena
J. HUDSON POOLE	Pasadena

OFFICERS

ARTHUR H. FLEMING.	President Emeritus
Allan C. Balch	President
HENRY M. ROBINSON	First Vice-President
HIRAM W. WADSWORTH	
Edward C. Barrett	

FINANCE COMMITTEE

Allan C. Balch, Chairman William L. Honnold Harvey S. Mudd Ben R. Meyer James R. Page Louis D. Ricketts

Administrative Officers of the Institute

EXECUTIVE COUNCIL

Robert A. Millikan, Chairman	HARVEY S. MUDD
Allan C. Balch	WILLIAM B. MUNBO
GEORGE E. HALE	ARTHUR A. NOYES
THOMAS H. MORGAN	HENRY M. ROBINSON
EDWARD C. BARRETT	, Secretary

CHAIRMEN OF DIVISIONS

ROBERT A. MILLIKAN Physics,	Mathematics, and Electrical Engineering
ARTHUR A. NOYES	Chemistry and Chemical Engineering
FRANKLIN THOMAS	Civil and Mechanical Engineering
JOHN P. BUWALDA	Geological Sciences
THOMAS H. MORGAN	Biology
CLINTON K. JUDY	Humanities
ROYAL W. SORENSEN	Physical Education

OTHER OFFICERS

EDWARD C. BARRETT.	Comptroller
RICHARD C. TOLMAN	
FREDERIC W. HINRICHS, JR.	Dean of Upper Classmen
JOHN R. MACARTHUR	Dean of Freshmen
PHILIP S. FOGG	Registrar
W. NOEL BIRCHBY	Assistant Registrar

Advisory Council

GANO DUNN, President, J. G. White Corporation.

FRANK B. JEWETT, President, Bell Telephone Laboratories, Inc., and Vice-President, American Telephone and Telegraph Company.

JOHN C. MERRIAM, President, Carnegie Institution of Washington.

CHARLES L. REESE, Chemical Director, E. I. du Pont de Nemours and Company.

Officers and Committees of the Faculty

OFFICERS

CHAIRMAN, WILLIAM V. HOUSTON SECRETARY, H. C. Van Buskirk

FACULTY BOARD

CHARMAN, Earnest C. Watson; SECRETARY, H. C. Van Buskirk; E. C. Barrett, S. J. Bates, J. E. Bell, H. Borsook, J. P. Buwalda, R. L. Daugherty, P. S. Fogg, F. W. Hinrichs, Jr., W. V. Houston, C. K. Judy, J. R. Macarthur, W. W. Michael, R. A. Millikan, T. H. Morgan, W. B. Munro, A. A. Noyes, L. Pauling, W. R. Smythe, R. W. Sorensen, F. Thomas, R. C. Tolman, Morgan Ward.

FACULTY COMMITTEES

ADMISSION TO UPPER CLASSES, Chairman, S. J. Bates Assembly, Chairman, C. K. Judy COMMENCEMENT EXERCISES, Chairman, L. W. Jones COURSE IN ENGINEERING, Chairman, W. W. Michael COURSE IN SCIENCE, Chairman, W. R. Smythe FRESHMAN ADMISSION AND REGISTRATION, Chairman, J. E. Bell GRADUATE COURSES OF STUDY, Chairman, R. C. Tolman HONOR STUDENTS, Chairman, Morgan Ward LECTURERS AND VISITS FOR OUTSIDE ORGANIZATIONS, Chairman, R. E. Untereiner MUSICAL ACTIVITIES, Chairman, F. Thomas PHYSICAL EDUCATION, Chairman, R. W. Sorensen PUBLICATIONS, Chairman, P. S. Fogg PUBLICITY, Chairman, E. C. Barrett REGISTRATION, Chairman, P. S. Fogg RELATIONS TO HIGH SCHOOLS, Chairman, E. C. Watson STUDENT AID, Chairman, F. W. Hinrichs, Jr. STUDENT BODY FINANCE, Chairman, H. N. Gilbert STUDENT HEALTH, Chairman, H. Borsook STUDENT RELATIONS, Chairman, F. Thomas STUDENT SOCIAL FUNCTIONS, Chairman, L. W. Jones

Staff of Instruction and Research

ROBERT ANDREWS MILLIKAN, PH.D., LL.D., Sc.D., Nobel Laureate Professor of Physics

Director of the Norman Bridge Laboratory of Physics

Chairman of the Executive Council

Chairman of the Executive Council
A.B., Oberlin College, 1891; A.M., 1893; Ph.D., Columbia University, 1895. Assistant in Physics, University of Chicago, 1896-1897; Associate, 1897-1899; Instructor, 1899-1902; Assistant Professor, 1902-1907; Asso-ciate Professor, 1907-1910; Professor, 1910-1921. Sc.D. (hon.), Oberlin College, 1911; Northwestern University, 1913: University of Pennsyl-vania, 1915; Amherst College, 1917; Columbia University, 1917; Uni-versity of Dublin, 1924; Yale University, 1925; Leeds University, 1927; Princeton University, 1928; New York University, 1929; Harvard Uni-versity, 1932, University of Rochester, 1934; LL.D., University of Cali-fornia, 1924; University of Colorado, 1927; University of Michigan, 1929 University of Southern California, 1931; Ph.D. (hon.), King John Casimir University, Lwów, Poland, 1926; University of Ghent, 1927; Mills College, 1935; Docteur Honoris Causa, University of Liege, 1930; Vice-President, American Association for the Advancement of Science, 1911; President, 1929; President American Physical Society, 1916-1018; Vice-President, American Association for the Advancement of Science, 1911; President, 1929; President American Physical Society, 1916-1918; Lieutenant Colonel, U. S. A., and Chief, Science and Research Division of Signal Corps, 1917-1919; American Representative, Troisième Conseil de Physique, Solvay, Brussels, 1921; Exchange Professor, Belgium, 1922; American Representative, Committee on Intellectual Cooperation, League of Nations, 1922-1932. Fellow of the Oberlaender Trust, 1931. Member, American Philosophical Society, National Academy of Sciences, American Academy of Arts and Sciences. Corresponding Member, Société Batave de Philosophie Expérimentale à Rotterdam, Académie des Sciences de Russie, Institut de France Académie des Sciences, Royal Accademia della Scienze Dell' Istituto Bologna, Accademie Lincei, Rome. Hon. Member, Royal Institution of Great Britain, La Société de Rome. Hon. Member, Royal Institution of Great Britain, La Société Hollandaise des Sciences, Royal Irish Academy, Die Gesellschaft der Wissenschaften zu Göttingen, Baveresche Akademie der Wissenschaft-ten zu Muenchen, Association des Ingénieurs de Liège, Kaiserlich Deutsche Akademie der Naturforscher; Associate of the Royal Acad-emy of Belgium, 1935. Recipient of Comstock Prize, National Academy of Sciences, 1913; of Edison Medal of the American Institute of Elec-trical Engineers, 1922; of the Nobel Prize in Physics of the Royal Swedish Academy, 1923; of the Faraday Medal of the Royal Society of Great Britain, 1923; of the Faraday Medal of the Societa Italiana della Scienze, 1925; of the Gold Medal of the Society of Mechanical Engineers, 1926; of the Messel Medal of the Society of Mechanical Engineers, 1926; of the Gold Medal of the Society of Arts and Sciences, 1920; and of the Gold Medal of the Rosevelt Memorial Foundation, 1930; and of the Gold Medal of Honor, Roosevelt Memorial Foundation, 1932. Chevalier de l'Ordre National de la Légion d' Honneur, 1931. California Institute, 1916-

1640 Oak Grove Avenue

THOMAS HUNT MORGAN, PH.D., LL.D., Sc.D., Nobel Laureate

Chairman of the Division of Biology, William G. Kerckhoff Laboratories of the Biological Sciences

Member of the Executive Council

B.S., University of Kentucky, 1886; M.S., 1888; Fh.D., Johns Hopkins University, 1890. Professor of Biology, Bryn Mawr College, 1891-1904; Professor of Experimental Zoology, Columbia University, 1904-1928. LL.D., Johns Hopkins University, 1915; University of Kentucky, 1916; McGill University, 1921; University of Edinburgh, 1922; University of California, 1930; Sc.D. (hon.), University of Michigan, 1924; Docteur Honoris Causa, University of Paris, 1935; I^h.D. (Dr. of Nat. Phil.), Heidelberg University, 1931. M.D. (hon.), University of Zurich, 1933. Fellow

of the American Association for the Advancement of Science (President, 1930); Member, American Philosophical Society; President, National Academy of Sciences, 1927-1931; Member, Linnean Society of London; Royal Society of Sciences of Denmark; Foreign Member, Royal Society of London; Finnish Society of Sciences; Associate Member, Société Roy-ale des Sciences Médicales et Naturelles de Bruxelles; Society Belge de Biologie, Bruxelles; Société de Biologie de France; Corresponding Member, Zoological Society of London; Académie des Sciences de Russie; Bavarian Academy of Sciences; Honorary Member, Royal Irish Academy; Ordinary Member, Royal Society of Sciences of Upsala; Foreign Associate, Royal Accademia Nazionale dei Lincei, Rome; Correspondent, Academie des Sciences, Institut de France. Recipient of the Nobel Prize in Medicine of the Swedish Royal Acad-emy, 1933. California Institute, 1928-1149 San Pasqual Street

WILLIAM BENNETT MUNRO, PH.D., LL.D., LITT.D.

Professor of History and Government Member of the Executive Council

Member of the Executive Council A., Queens University, 1895; M.A., 1896; LL.B., 1898; M.A., Harvard University, 1899; Ph.D., 1900, M.A. (hon.), Williams College, 1904; LL.D., Queens University, 1912; Litt.D., University of Southern California, 1930; Parker Traveling Fellow, Harvard University, 1900-1901; Instructor in History and Political Science, Williams College, 1901-1904; Instructor in Government, Harvard University, 1904-1906; Assistant Professor of Government, 1906-1912; Professor of American History and Government, 1925-1930; Chairman of the Division of His-tory, Economics and Government, Harvard University, 1920-1928; Weil Foundation Lecturer, University of North Carolina, 1921; Mc-Bride Foundation Lecturer, Western Reserve University, 1925; Jacob H. Schiff Foundation Lecturer, Cornell University, 1925; Marfieet Lec-turer, University of Toronto, 1929; President of the American Asso-ciation of University Professors, 1930-1931; President of the American Asso-ciation for the Advancement of Science, 1931. Fellow of the American Academy of Arts and Sciences. California Institute, 1925-268 Bellefontaine Street В.А.,

268 Bellefontaine Street

ARTHUR AMOS NOYES, PH.D., LL.D., Sc.D. Professor of Chemistry Director of the Gates Chemical Laboratory Member of the Executive Council

 Member of the Executive Council
 S.B., Massachusetts Institute of Technology, 1886; S.M., 1887; Ph.D., University of Leipzig, 1890; LL.D., University of Maine, 1908; Clark University, 1909; University of Pittsburgh, 1915; Sc.D. (hon.), Harvard University, 1909; Yale University, 1913. Assistant and In-structor in Analytical Chemistry, Massachusetts Institute of Tech-nology, 1887-1892; Instructor in Organic Chemistry, 1892-1894; Assis-tant and Associate Professor of Organic Chemistry, 1894-1899; Pro-fessor of Theoretical Chemistry, 1899-1919; Director of the Research Laboratory of Physical Chemistry, 1903-1919. Acting President, Massachusetts Institute of Technology, 1907-1909; President, American Chemical Society, 1904; President, American Association for Advance-ment of Science, 1927; Honorary Fellow, Royal Society of Edinburgh; Member, National Academy of Sciences, American Philosophical Society, and American Academy of Arts and Sciences. Willard Gibbs Medal, American Chemical Society, 1915. Davy Medal, Royal Society, 1927; Richards Medal, American Chemical Society, 1932. California Institute, 1913-1025 San Pasqual Street Institute, 1913-1025 San Pasqual Street

EDWARD CECIL BARRETT, B.A.

Comptroller

B.A., State University of Iowa, 1906. Assistant Secretary, Board of Re-gents, 1906-1907; Registrar and Secretary to the President, State University of Iowa, 1907-1911. California Institute, 1911-

942 North Chester Avenue

HARRY BATEMAN, PH.D.

Professor of Mathematics, Theoretical Physics, and Aeronautics

 B.A., Cambridge University, 1903; Smith Prize, 1905; Fellowship, Trinity College, Cambridge, 1905-1911; Universities of Göttingen and Paris. 1905-1906; M.A., Cambridge University, 1906; Ph.D., Johns Hopkins University, 1913. Lecturer in Mathematics, University of Liverpool, 1906-1907; Reader in Mathematical Physics, University of Manchester, 1907-1910; Lecturer in Mathematics, Bryn Mawr College, 1910-1912; Lecturer in Applied Mathematics, Johns Hopkins University, 1915-1917. Fellow of the Royal Society of London, 1928. Member, American Philosophical Society, National Academy of Sciences. California Insti-tute, 1917tute, 1917-

1107 San Pasqual Street

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 Chem-istry, University of Illinois, 1910-1912; Research Associate in Physical Chemistry, 1912-1913. Instructor in Analytical Chemistry, University of Illinois, 1913-1914; Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1922-1923 (on leave from Cali-fornia Institute of Technology). California Institute, 1914-

2011 Rose Villa Street

ERIC TEMPLE BELL, PH.D. Professor of Mathematics

A.B., Stanford University, 1904; A.M., University of Washington, 1908; Ph.D., Columbia University, 1912. Instructor, Assistant Professor, Associate Professor, University of Washington, 1912-1922; Professor, 1922-1928. Bécher Prize, American Mathematical Society, 1924; Vice-President, American Mathematical Society, 1926.; Colloquium Lec-turer, American Mathematical Society, 1927. Professor, summer quarters, University of Chicago, 1924-1928; Visiting Lecturer, Harvard University, first half 1926. Vice-President, American Association for the Advancement of Science, 1929-1930; President, Mathematical Asso-ciation of America, 1931-. Member of National Academy of Sciences. California Institute, 1926-434 South Michigan Avenue

434 South Michigan Avenue

JAMES EDGAR BELL, PH.D.

Professor of Chemistry

S.B., University of Chicago, 1905; Ph.D., University of Illinois, 1913. Graduate student, University of Chicago, 1908-1910. Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916. Associate Professor, California Institute, 1916-1918; Professor, 1918-

R. D. 1, Box 639, Pasadena

HENRY BORSOOK, PH.D.

Professor of Biochemistry

B.A., University of Toronto, 1921; M.A., 1922; Ph.D., 1924; M.B., 1927. Fellow, Research Fellow, and Lecturer in Biochemistry, University of Toronto, 1920-1929. Assistant Professor, California Institute, 1929-1935; Professor, 1935-

1121 Constance Street

IRA SPRAGUE BOWEN, PH.D.

Professor of Physics

A.B., Oberlin College, 1919; Ph.D., California Institute of Technology, 1926. Assistant in Physics, University of Chicago, 1920-1921. Instructor, California Institute, 1921-1926; Assistant Professor, 1926-1928; Associate Professor, 1922-1931; Professor, 1931-

380 Bonita Avenue

JOHN PETER BUWALDA, PH.D.

Professor of Geology

B.S., University of California, 1912; Ph.D., 1915. Instructor, University of California, 1915-1917; Assistant Professor of Geology, Yale University, 1917-1921; Associate Professor of Geology, University of California, 1921-1925; Professor of Geology, 1925; Dean of the Summer Sessions, 1923-1925. Associate Geologist, U. S. Geological Survey. Member, Federal Advisory Board for Yosemite National Park, 1928-. California Institute, 1925-

2103 San Pasqual Street

W. HOWARD CLAPP, E.M.

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. Instructor, California Institute, 1911-1913; Assistant Professor, 1913-1914; Associate Professor, 1914-1918; Professor, 1918-

95 South Mentor Avenue

ROBERT L. DAUGHERTY, M.E.

Professor of Mechanical and Hydraulic Engineering

A. B. in Mechanical Engineering, Leland Stanford Junior University, 1909; M. E., 1914. Assistant in Mechanics, Leland Stanford Junior University, 1907-1908; Assistant in Hydraulics, 1908-1909; Instructor in Mechanical Engineering, 1909-1910; Assistant Professor of Hydraulics, Sibley College, Cornell University, 1910-1916; Professor of Hydraulics Engineering, Rensselaer Polytechnic Institute, 1916-1919. Member of Council, American Society of Mechanical Engineers, 1928-1928; Vice-President, 1928-1930. Vice-Chairman and Chairman, Board of Directors, City of Pasadena, 1927-1931. California Institute, 1919-

373 South Euclid Avenue

PAUL SOPHUS EPSTEIN, PH.D.

Professor of Theoretical Physics

C.Sc., Moscow University, 1906; M.Sc., 1909; Ph.D., University of Munich, 1914. Assistant in Physics, Moscow Institute of Agriculture, 1906-1907; Assistant in Physics, Moscow University, 1907-1909; Privat docent, Moscow University, 1909-1913; Privat docent, University of Zurich, 1919-1922. Member National Academy of Sciences. California Institute. 1921-

1484 Oakdale Street

BENO GUTENBERG, PH.D.

Professor of Geophysics

Technische Hochschule, Darmstadt, 1907; Universität Göttingen, 1908; Ph.D., 1911. Assistant Zentral Büro der Internationalen Seismolo-gischen Vereinigung, Strassburg, 1913-1914; Reichszentrale fuer Erd-bebenforschung, Strassburg, 1914-1919; Privatdozent fuer Geophysik, Universität Frankfurt A/M, 1924-1926; A. O. Professor, 1926-1930. California Institute, 1930-

399 Ninita Parkway

FREDERIC W. HINRICHS, JR., M.A.

Professor of Mechanics

Dean of Upper Classmen

A.B., Columbia University, as of 1902. M.A. (hon.), Occidental College, 1926. Graduate of the United States Military Academy, West Point, 1902. Assistant Professor, Professor of Applied Mechanics, University of Rochester, 1910-1919. Assistant Professor, California Institute, 1920-1923; Professor and Dean, 1923-

1071 North Garfield Avenue

WILLIAM VERMILLION HOUSTON, PH.D. Professor of Physics

٠.

B.A. and B.Sc. in Ed., Ohio State University, 1920; M.S., University of Chicago, 1922; Ph.D., Ohio State University, 1925. Instructor in Physics, Ohio State University, 1922-1925. National Research Fellow in Physics, 1925-1927. Foreign Fellow of the John Simon Guggenheim Foundation, 1927-1928. National Research Fellow, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

134 North Rosemont Avenue, Alhambra

CLINTON KELLY JUDY. M.A.

Professor of English Language and Literature

A.B., University of California, 1903; M.A., 1907; B.A., Oxford University 1909; M.A., 1913; M.A., Harvard University, 1917. California Institute 1909-

1325 Woodstock Road, San Marino

CALIFORNIA INSTITUTE OF TECHNOLOGY

THEODOR VON KÁRMÁN, PH.D., DR. ING. Professor of Aeronautics

Director of the Daniel Guggenheim Laboratory

M.E., Budapest, 1902; Ph.D., Göttingen, 1908. Honorary degree of Doctor of Engineering, University of Berlin, 1929. Privat docent, Göttingen, 1910-1913; Professor of Mechanics and Aerodynamics, Director of the Aerodynamical Institute, University of Aachen, 1913-1934; Honorary Adviser of the Aeronautical Department of Thing Hua University (China), 1933- Member of Gesellschaft de Wissenschaften zu Göttingen, 1925; foreign member of the Royal Academy of Sciences, Torino, 1928. California Institute, 1928-

1501 South Marengo Avenue

WILLIAM NOBLE LACEY, PH.D.

Professor of Chemical Engineering

A.B. in Chemical Engineering, 1911, and Chemical Engineer, 1912, Leland Stanford Junior University; M.S., 1913; Ph.D., University of Califor-nia, 1915. Assistant in Chemistry, Leland Stanford Junior University, 1911-1912; Assistant in Chemistry, University of California, 1912-1915; Research Chemist for Giant Powder Co., San Francisco, 1915; Re-search Associate, Massachusetts Institute of Technology, 1916. In-structor, California Institute, 1915-1917; Assistant Professor, 1917-1919; Associate Professor, 1919-1931; Professor, 1931-2126 Mincom Drive

2136 Minoru Drive

GRAHAM ALLAN LAING, M.A.

Professor of Economics and Business Administration

 B.A., University of Liverpool, 1908; M.A., 1909; Gladstone Prize in History and Political Science, Rathbone Prize in Economics, Liverpool Uni-versity, 1907; Workers' Educational Association Lecturer in Economic History for Liverpool University, 1909-1913; Secretary, Department of Education, Government of British Columbia, 1913-1914; Director of Technical Education, Vancouver, B. (2019), 1917; Instructor in Eco-nomics and History, University of California, 1917-1918; Assistant Statistician, United States Shipping Board, 1918-1919; Assistant Pro-fessor of Social Science, University of Arizona, 1919-1921. California Institute, 1921-1642 Pleasant Way

CHARLES CHRISTIAN LAURITSEN, PH.D. Professor of Physics

Odense Tekniske Skole, 1911; Ph.D., California Institute of Technology, 1929. Assistant in Physics, California Institute, 1927-1930; Assistant Professor, 1930-1931; Associate Professor, 1931-1935; Professor, 1935-1444 Blanche Street

JOHN ROBERTSON MACARTHUR, PH.D. Professor of Languages Dean of Freshmen

 B.A., University of Manitoba, 1892; Ph.D., University of Chicago, 1903. Lecturer in Modern Languages, Manitoba College, 1893-1898; Professor of English, New Mexico Agricultural College, 1903-1910, 1911-1913; Professor of English, Kansas State Agricultural College, 1914-1920. Agent of International Committee of Young Men's Christian Asso-clation, Ellis Island, 1910-1911. Associate Professor, California Institute, 1920-1923; Professor and Dean, 1923-

866 South Pasadena Avenue

ROMEO RAOUL MARTEL, S.B.

Professor of Structural Engineering

S.B., Brown University, 1912. L. Brown University, 1912. Instructor in Civil Engineering, Rhode Island State College, 1913-1914; Instructor in Civil Engineering, Mechanics Institute, 1914-1915. With Sayles Finishing Plants, Sayles-ville, R. I., 1915-1918; with Atchison, Topeka and Santa Fe Railway, Amarillo, Texas, 1918; Resident Engineer, California Highway Com-mission, Willits, California, summer of 1921. Consulting Engineer on Bridge Design for City of Pasadena, 1921-1924. Representative of Southern California Council on Earthquake Protection at Third Pan-Pacific Science Congress, Tokyo, 1926, and at the World Engineering Congress at Tokyo in 1929. Instructor, California Institute, 1918-1920; Assistant Professor, 1920-1921; Associate Professor, 1921-1930; Pro-Instructor in Civil Engineering, Rhode fessor, 1930-

690 South Mentor Avenue

SEELEY G. MUDD. M.D.

Professor of X-Ray Therapy Director of Radiological Research

B.S., Columbia University, 1917; M.D., Harvard University, 1924. Research Associate in Radiation, California Institute, 1931-1935; Professor, 1935-

1550 Oak Grove Avenue

LINUS PAULING, PH.D., Sc.D.

Professor of Chemistry

B.S., Oregon State Agricultural College, 1922; Ph.D., California Institute of Technology, 1925. Sc.D. (hon.), Oregon State Agricultural College, 1933. National Research Fellow in Chemistry, 1925-1926. Foreign Fellow of the John Simon Guggenheim Memorial Foundation, 1926-1927. Lecturer in Physics and Chemistry, University of California, 1928-1933. Massachusetts Institute of Technology, 1932. Langmuir Prize of the American Chemical Society, 1931. Member of National Academy of Sciences. Assistant in Chemistry, California Institute, 1922-1923; Teaching Fellow, 1923-1925; Research Fellow, 1926-1927; Assistant Pro-fessor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

1245 Arden Road

SVERRE PETTERSSEN, DR. PHIL.

Visiting Professor of Meteorology

Cand. Real., University of Oslo, 1926; Dr. Phil., 1932. Director of Meteoro-logical Institute, Bergen, 1931-. California Institute, 1935.

Athenæum

THEODORE GERALD SOARES, PH.D., D.D. Professor of Ethics

A.B., University of Minnesota, 1891; A.M., 1892; Ph.D., University of Chi-cago, 1894; D.B., 1897; D.D., Knox College, 1901. Professor of Homi-letics, University of Chicago, 1906-1908; Professor of Religious Educa-tion and Head of the Department of Practical Theology, 1908-1930. President, Religious Education Association, 1921-1924. California In-

1542 Morada Place, Altadena

ROYAL WASSON SORENSEN, E.E. Professor of Electrical Engineering

 B.S., in Electrical Engineering, University of Colorado, 1905; E.E., 1928. Associated with General Electric Co., Schenectady, N. Y., and Pitts-field, Mass., 1905-1910; Consulting Engineer, Pacific Light and Power Corporation, 1913-1917. Consulting Engineer, U. S. Electrical Manu-facturing Company, 1917-1929, 1930-32. Consulting Engineer, Circuit Breaker Research Department, General Electric Company, 1929-1930. Member, Board of Consulting Engineers, Metropolitan Water District of Southern California, 1931-. Associate Professor, California Institute, 1910-11; Professor, 1911-384 South Holliston Avenue

CHESTER STOCK, PH.D. Professor of Paleontology

 B.S., University of California, 1914; Ph.D., 1917; Research Assistant, Department of Paleontology, University of California, 1917-1919; Instructor, 1919-1921; Assistant Professor, Department of Geological Sciences, 1921-1925. Research Associate, Carnegie Institution of Washington. Curator of Vertebrate Paleontology, Los Angeles Museum. California Institute, 1926 1633 Linda Vista Avenue 1633 Linda Vista Avenue

ALFRED HENRY STURTEVANT, PH.D. Professor of Genetics

A.B., Columbia University, 1912; Ph.D., 1914. Research Assistant, Car-negie Institution, 1915-1928. Member of National Academy of Sciences. California Institute, 1928-

1244 Arden Road

FRANKLIN THOMAS, C.E. Professor of Civil Engineering

B.E., University of Iowa, 1908; C.E., 1913. Graduate work at McGill Uni-L. University of Iowa, 1908; C.E., 1913. Graduate work at McGill University, Montreal. Instructor in Descriptive Geometry and Drawing, University of Michigan, 1910-1912. Construction Foreman, Mines Power Company, Cobalt, Ontario, 1909-1910; Designer, Alabama Power Company, Birmingham, Alabama, 1912-1913. Assistant Engineer, U. S. Reclamation Service, 1919. Member and Vice-Chairman, Board of Directors, City of Pasadena, 1921-1927; Member and Vice-Chairman, Board of Directors, Metropolitan Water District, 1928-; Director, American Society of Civil Engineers, 1930-. Associate Professor, California Institute, 1913-1914; Professor, 1914-6825 South F! Moling Avenue.

685 South E! Molino Avenue

RICHARD CHACE TOLMAN, PH.D. Professor of Physical Chemistry and Mathematical Physics Dean of the Graduate School

Dean of the Graduate School S.B. in Chemical Engineering, Massachusetts Institute of Technology, 1903; Ph.D., 1910; Student, Berlin and Crefeld, 1903-1904. Dalton Fel-low, Instructor in Theoretical Chemistry, and Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1905-1910; Instructor in Physical Chemistry, University of Michigan, 1910-1911; Assistant Professor of Physical Chemistry, University of California, 1912-1916; Professor of Physical Chemistry, University of California, 1912-1916; Professor of Physical Chemistry, University of Illinois, 1916-1918; Chief, Dispersoid Section, Chemical Warfare Service, 1918; Asso-ciate Director and Director, Fixed Nitrogen Research Laboratory, Department of Agriculture, 1919-1921. Member of National Academy of Sciences, American Philosophical Society, and of American Acad-emy of Arts and Sciences. California Institute, 1921emy of Arts and Sciences. California Institute, 1921-

345 South Michigan Avenue

HARRY CLARK VAN BUSKIRK, PH.B. Professor of Mathematics

Ph.B., Cornell University, 1897. Associate Professor, California Institute, 1904-1915; Professor, 1915-390 South Holliston Avenue

EARNEST CHARLES WATSON, PH.B. Professor of Physics

 Ph.B., Lafayette College, 1914; Assistant in Physics, University of Chicago, 1914-1917. Assistant Professor, California Institute, 1919-1920; Associate Professor, 1920-1930; Professor, 1930-1124 Mar Vista Avenue

FRITS WARMOLT WENT, PH.D.

Professor of Plant Physiology

A.B., Utrecht, 1922; A.M., 1925; Ph.D., 1927. Assistant in Botanical Laboratory, 1924-1927; Assistant, Lands Plantentuin, Beutenzorg, Java, 1927-1930; Director, Foreigners' Laboratory, Java, 1930-1932. Corresponding Member, Koninklijk Akademie van Wetenschappen te Amsterdam. Assistant Professor, California Institute, 1932-1935; Professor, 1935-

200 South Catalina Avenue

DINSMORE ALTER, PH.D.

.

Research Associate in Statistics

B.S., Westminster College (Pa.), 1909; M.S., University of Pittsburgh, 1910;
 Ph.D., University of California, 1916. Instructor in Physics and Astronomy, University of Alabama, 1911-1912, Assistant Professor, 1912-1913,
 Adjunct Professor, 1913-1914; Instructor in Astronomy, University of California, 1914-1917; Assistant Professor of Astronomy, University of Kansas, 1917-1919; Associate Professor, 1919-1924; Professor, 1924-; Director, Griffith Observatory, Los Angeles, 1935-. Guggenheim Memorial Foundation Fellow, England, 1929-1930. Fellow of the Royal Astronomical Society. California Institute, 1935-

Griffith Observatory, Los Angeles

JOHN AUGUST ANDERSON, PH.D

Research Associate in Astrophysics* Executive Officer of the Observatory Council

 B.S., Valparaiso College, 1900; Ph.D., Johns Hopkins University, 1907. Associate Professor of Astronomy, Johns Hopkins University, 1908-1916; Physicist, Mount Wilson Observatory, 1916-. California Institute, 1928-994 Poppy Street, Altadena

*Member of the staff of the Mount Wilson Observatory of the Carnegle Institution of Washington. Associated with the California Institute by special arrangement with the Carnegie Institution.

SAMUEL JACKSON BARNETT, PH.D.

Research Associate in Physics

A.B., University of Denver, 1894; Ph.D., Cornell University, 1898. Instructor in Physics and Biology, University of Denver, 1894-1895; Assistant in Astronomical Observatory, University of Virginia, 1895-1896; University Scholar and President White Fellow, Cornell University, 1896-1898; Instructor in Physics and later Professor of Physics, Colorado College, 1898-1900; Assistant Professor of Physics, Stanford University, 1900-1905; Professor of Physics, Tulane University of Louisiana, 1905-1911; Assistant Professor of Physics, 1911-1912, and Professor of Physics, 1912-1913, Ohio State University; Physicist, Carnegie Institution of Washington, 1918-1926 (Research Associate, 1924-1926); Professor of Physics, University of California at Los Angeles, 1918; Fellow of the American Academy of Arts and Sciences. California Institute, 1923-

939 Thayer Avenue, Westwood Hills, Los Angeles

HARDIN CRAIG, PH.D.

Associate in English

 B.A., Centre College, 1897; M.A., Princeton University, 1899; Ph.D., 1901.
 Charles Scribner Fellow in English, Princeton University, 1899-1901; Instructor in English, 1901-1905; Egerstoune Preceptor in English, 1905-1910; Frofessor of English, University of Minnesota, 1910-1919; Professor of English and Head of Department, State University of Iowa, 1919-1928; Professor of English, Stanford University, 1928-.
 Research Associate, Huntington Library, 1930-. California Institute, 1930-1931, 1933-1934, 1935-1936.

Athenæum

GODFREY DAVIES, M.A.

Associate in History

B.A., Honour School of Modern History, Oxford University, 1914; Secretary to C. H Firth, then Regius Professor of Modern History, Oxford University, 1914-1916; Tutor in the School of Modern History, 1919-1924; Assistant Professor of History, University of Chicago, 1925-1930. Visiting Scholar of the Huntington Library, 1930-1931; Member of Research Staff, 1931-. California Institute, 1930-

430 South San Marino Avenue

JESSE WILLIAM MONROE DUMOND, PH.D.

Research Associate in Physics

B.S., California Institute of Technology, 1916; M.S. in E.E., Union College, 1918; Ph.D., California Institute, 1929. Teaching Fellow, California Institute, 1921-1925; Research Fellow, 1925-1931; Research Associate, 1931-

1585 Homewood Drive, Altadena

JOSEPH BLAKE KOEPFLI, D.PHIL.

Research Associate in Chemistry

A.B., Leland Stanford Junior University, 1924; M.A., 1925; D. Phil., Oxford University, 1928. Research Fellow in Organic Chemistry, California Institute, 1928-1929. Instructor in Pharmacology, Johns Hopkins University School of Medicine, 1929-1931. California Institute, 1932-

1101 San Pasqual Street

Alfred E. Mirsky, Ph.D. Visiting Research Associate in Chemistry

A.B., Harvard University, 1922; Ph.D., University of Cambridge, 1926. National Research Fellow in Medicine, 1924-1926; Assistant in Medicine, Hospital of the Rockefeller Institute, New York City, 1927-1930; Re-search Associate in Medicine, 1930-. California Institute, 1935-

1436 Oakdale Street

CLYDE STANLEY MCDOWELL, Captain U. S. N.* Supervising Engineer for the 200-inch Telescope

Supervising Engineer for the 200-inch Telescope
 Graduate U. S. Naval Academy, 1904; promoted Commander, 1918; Captain, 1926.
 Sc.D. (hon.), University of Wisconsin, 1921. In charge of Physical and Electrical Laboratories, New York Navy Yard, 1912-1915; Staff Commander, U. S. Submarine Forces, 1915-1918; member and executive secretary, U. S. Anti-Submarine Board, 1917-1918; command Naval Experiment Station, New London, Connecticut, 1917-1918; Staff Commander, U. S. Navał Forces in European waters, 1918-1919; Naval Inspector of Machinery and Inspector of Ordnance, General Electric Company, Schenectady, 1912-1922; Staff Commander, Base Forces, U. S. Fleet, 1922-1924; Chief Engineer, Mare Island Navy Yard, 1924-1927; Manager, Navy Yard, Pearl Harbor, T. H., 1929-1930; Inspector of Machinery, Westinghouse Electric and Manufacturing Compario, 1932-194; Inspector of Machinery, New York Shipbuilding Corporation, Camden, N. J., 1933-1934. Awarded Navy Cross for war work. California Institute, 1934-

745 South Oak Knoll Avenue

ROBERT THOMAS MOORE, A.M. Associate in Vertebrate Zoology

A.B., University of Pennsylvania, 1903; A.M., Harvard University, 1904; University of Munich, 1904-1905. Fellow of the Royal Geological Society (London), American Geological Society; member of American Ornithological Union. California Institute, 1929-

Meadow Grove Avenue, Flintridge

FREDERICK M. PADELFORD, PH.D.

Associate in English Literature

A.B., Colby College, 1896; A.M., 1899; Ph.D., Yale University, 1899; research work at the British Museum and at Oxford University. Professor of English, University of Idaho, 1899-1901; Professor of English, Univer-sity of Washington, 1901-, and Dean of the Graduate School, 1920-. Visiting Scholar of the Huntington Library, 1935-1936. California Institute, 1935-1936.

285 North San Rafael Avenue

FRANCIS GLADHEIM PEASE, D.Sc.

Associate in Optics and Instrument Design**

B.S., Armour Institute of Technology, 1901; M.S., 1924, D.Sc., 1927. Optician and Observer, Yerkes Observatory, 1901-1904; Instrument Designer, Mount Wilson Observatory, 1904-1913; Astronomer, 1911-, In Charge of Instrument Design, 1913-. Chief Draftsman, National Research Council, 1918. Fellow of Royal Astronomical Society, London. California Institute, 1928 824 North Holliston Avenue

*On leave of absence from the U.S. Navy.

**Member of the staff of the Mount Wilson Observatory of the Car-negie Institution of Washington. Associated with the California Institute by special arrangement with the Carnegie Institution.

RUSSELL WILLIAMS PORTER. M.S.

Associate in Optics and Instrument Design

M.S. (hon.), Norwich University, 1917. Made eight trips to Arctic Regions with Peary, Fiala-Ziegler, and Baldwin-Ziegler as artist, astronomer, topographer, surveyor, or collector for natural history; three trips into Alaska, British Columbia, and Labrador. Instructor in architecture, Massachusetts Institute of Technology, 1916-1917; optical work, Bureau of Standards, Washington, D. C., 1917-1918; Optical Associate with the Jones & Lamson Machine Co., 1918-1928. California Institute, 1928-

615 South Mentor Avenue

CARL CLAPP THOMAS, M.E.

Associate in Engineering Research

Associate in Engineering Research Stanford University, 1891-1894; M.E., Cornell University, 1895. Engaged in Design and Construction of Marine Machinery for Merchant and Naval Vessels, 1895-1904. Professor of Marine Engineering, Cornell University, 1904-1908. Chairman, Department of Mechanical Engi-neering, University of Wisconsin, 1908-1913; Head of Department of Mechanical Engineering, Johns Hopkins University, 1913-1920. Man-ager, Machinery Design and Fabrication, United States Government, Hog Island Shipyard, 1917-1919 (on leave from Johns Hopkins Uni-versity). Vice-President, Dwight P. Robinson & Company, Inc., Engineers and Constructors, 1923. Member American Engineering Council, 1923-. Longstreth Medalist, Franklin Institute, for work on measurement of gases, 1912. California Institute, 1925-

165 Linda Vista Avenue

HARRY OSCAR WOOD, M.A.

Research Associate in Seismology

A.B., Harvard University, 1902; A.M., 1904. Instructor in Mineralogy and Geology, University of California, 1904-1912; Research Associate in Seismology, Hawaiian Volcano Observatory of the Massachusetts In-stitute of Technology, 1912-1917; Research Associate in Seismology, Carnegie Institution of Washington, 1921-. California Institute, 1981-220 North San Rafael Avenue

LOUIS BOOKER WRIGHT, PH.D.

Associate in English Literature

3., Wolford College, 1920; M.A., University of North Carolina, 1924; Ph.D., 1926. Instructor in English, University of North Carolina, 1925-1927; Johnston Research Scholar, Johns Hopkins University, 1927-1928; Guggenheim Research Fellow in England and Italy, 1928-1929; Visiting Professor, Emory University, winter quarter, 1929; Assistant Professor of English, University of North Carolina, 1929-1930; Associate Professor, sor, 1930-1932. Visiting Scholar of the Huntington Library, 1931-1932; Member of the Research Staff, 1932-. California Institute, 1931-A.B.,

589 South Berkelev Avenue

ERNEST GUSTAF ANDERSON, PH.D. Associate Professor of Genetics

B.S., University of Nebraska, 1915; Ph.D., Cornell University, 1920. Re-search Associate, Carnegie Institution, 1920-1922; Instructor in Biology, College of the City of New York, 1922-1923. Fellow of the National Research Council, University of Michigan, 1923-1928. California Institute, 1928-831 Sunset Boulevard, Arcadia

÷.

IAN CAMPBELL, PH.D.

Associate Professor of Petrology

B.A., University of Oregon, 1922; M.A., 1924; Ph.D., Harvard University, 1931. Assistant Professor of Geology, Louisiana State University, 1925-1928; Instructor in Mineralogy and Petrology, Harvard University, 1928-1931; Geologist, Wisconsin Geological Survey, 1924; Petrologist, Vacuum Oil Company, 1926-1927; Petrologist, Panama Corporation, 1927-1928; Junior Geologist, United States Geological Survey, 1929-. Assistant Professor, California Institute, 1931-1934; Associate Professor, 1934-

627 Drexel Place

Roscoe Gilkey Dickinson, Ph.D.

Associate Professor of Physical Chemistry

S.B., Massachusetts Institute of Technology, 1915; Ph.D., California Institute of Technology, 1920. Assistant in Theoretical Chemistry, Massachusetts Institute of Technology, 1915-1916; Research Assistant in Physical Chemistry, 1916-1917. National Research Fellow in Chemistry, 1920-1923. Fellow of the International Education Board in Europe, 1924-1925. Instructor, California Institute, 1917-1920; National Research Fellow, 1920-1923; Research Associate, 1923-1926; Assistant Professor, 1926-1928; Associate Professor, 1928-

530 Bonita Avenue

HORACE NATHANIEL GILBERT, M.B.A. Associate Professor of Business Economics

A.B., University of Washington, 1923; M.B.A., Harvard University, 1926. Instructor in Business Policy, Harvard University, 1926-1928; Instructor in Business Economics, 1928-1929. Assistant Professor, California Institute, 1929-1930; Associate Professor, 1930-

3316 Evelyn Street

ALEXANDER GOETZ, PH.D.

Associate Professor of Physics

Ph.D., University of Göttingen, 1921; Habilitation, 1923. Assistant Professor of Physics, University of Göttingen, 1923-1927; a.o. Professor, 1929-. Fellow in Physics of the International Education Board, 1927-1928. Visiting Professor, Imperial Universities of Japan and University of Tsin-Hua, China, 1930. Research Fellow of International Education Board, California Institute, 1927-1928; Research Fellow, 1928-1929; Associate Professor, 1929-

1980 Meadowbrook Road

ARTHUR LOUIS KLEIN, PH.D.

Associate Professor of Aeronautics

B.S., California Institute of Technology, 1921; M.S., 1924; Ph.D., 1925. Teaching Fellow in Physics, California Institute, 1921-1925; Research Fellow in Physics and in Aeronautics, 1927-1929; Assistant Professor, 1929-1934; Associate Professor, 1934-

2771 Glendower Avenue, Los Angeles

HOWARD JOHNSON LUCAS. M.A. Associate Professor of Organic Chemistry

B.A., Ohio State University, 1907; M.A., 1908; Assistant in Organic Chem-istry, Ohio State University, 1907-1909; Fellow in Chemistry, Univer-sity of Chicago, 1909-1910; Chemist, Bureau of Chemistry, United States Department of Agriculture, 1910-1912. Chemist, Government of Porto Rico, 1912-1913. Instructor, California Institute. 1913-1915; Associate Professor, 1915-

97 North Holliston Avenue

SAMUEL STUART MACKEOWN, PH.D.

Associate Professor of Electrical Engineering

A.B., Cornell University, 1917; Ph.D., 1923. Instructor in Physics, Cornell University, 1920-1923. National Research Fellow in Physics, California Institute, 1923-1926: Assistant Professor, 1926-1931: Associate Professor, 1931 -

1240 Arden Road

GEORGE RUPERT MACMINN, A.B.

Associate Professor of English Language and Literature

A.B., Brown University, 1905. Instructor in English, Brown University, 1907-1909; Iowa State College, 1909-1910; University of California, 1910-1918. Manager of the University of California Press, 1912-1913. Editor, University of California Chronicle, 1915. Member of the Fac-ulty, Summer Sessions, University of California at Los Angeles, 1920-1931. California Institute, 1918-

255 South Bonnie Avenue

WILLIAM W. MICHAEL, B.S.

Associate Professor of Civil Engineering

B.S., in Civil Engineering, Tufts College, 1909. With New York City on topographic surveys, 1909-1911; with The J. G. White Engineering Corporation, 1912-1913 and 1915; Instructor, Department of Drawing and Design, Michigan Agricultural College, 1914; Office Engineer with The Power Construction Company of Massachusetts, 1914-1915; in private engineering practice, 1916-1918. Engineer, Palos Verdes Es-tates, summer of 1922; Associate and Consulting Engineer with County Engineer, Ulster County, N. Y., summers of 1925, 1928-1932. California Institute, 1918-

388 South Oak Avenue

ARISTOTLE D. MICHAL. PH.D.

Associate Professor of Mathematics

A.B., Clark University, 1920; A.M., 1921; Ph.D., Rice Institute, 1924. Teaching Fellow in Mathematics, Rice Institute, 1921-1924; Instructor in Mathematics, Summer Quarter, University of Texas, 1924; Instruc-tor in Mathematics, Rice Institute, 1924-1925; National Research Fel-low in Mathematics, 1925-1927; Assistant Professor of Mathematics, Ohio State University, 1927-1929. Associate Professor of Mathematics, California Institute, 1929-

2002 Oakdale Street

CLARK BLANCHARD MILLIKAN, PH.D.

Associate Professor of Aeronautics

A.B., Yale University, 1924; Ph.D., California Institute of Technology, 1928. Assistant in Physics, California Institute, 1925-1926; Teaching Fellow in Physics and in Aeronautics, 1926-1929; Assistant Professor, 1929-1934; Associate Professor, 1934-

1500 Normandy Drive

J. ROBERT OPPENHEIMER, PH.D.

Associate Professor of Theoretical Physics

B.A., Harvard University, 1925; Ph.D., University of Göttingen, 1927. Associate Professor of Theoretical Physics, University of California, 1930-. California Institute, 1928-

GENNADY W. POTAPENKO

Associate Professor of Physics

Dipl. in Phys., University of Moscow, 1917; Habilitation, 1920. Assistant in Physics, Moscow Institute of Petrographie, 1914-1916; Research Feilow, University of Moscow, 1917-1920; Docent of Physics, 1920-1932.
Professor of Physics, University of Iaroslawl, 1924-1926; Associate Professor, Mining Academie of Moscow, 1917-1927. Professor of Physics and Director of the Physical Institute, Mining Academy of Moscow, 1927-1932. Professor of Physics and Director of the Physical Institute, Agriculture Academie of Moscow, 1920-1931. Research Associate, University of Berlin, 1927; Visiting Lecturer, University of Göttingen, 1929. Recipient of Silver Medal, University of Moscow, 1914; of the Prize in Physics, Russian Scientific Council, 1928. Fellow of the Rockefeller Foundation, California Institute, 1930-1931; Research Fellow, 1931-1932; Associate Professor, 1932-

786 South Mentor Avenue

WILLIAM RALPH SMYTHE, PH.D.

Associate Professor of Physics

A.B., Colorado College, 1916; A.M., Dartmouth College, 1919; Ph.D., University of Chicago, 1921. Professor of Physics, University of the Philippines, 1921-1923. National Research Fellow, California Institute, 1923-1926; Research Fellow, 1926-1927; Assistant Professor, 1927-1934; Associate Professor, 1934-

674 Manzanita Avenue, Sierra Madre

WILLIAM L. STANTON, B.A.

Physical Director

B.A., Dickinson College, 1903. Assistant Director of Physical Education, Pratt Institute, 1903-1904; Director of Athletics and Physical Education, Morristown School, 1905-1906; Professor of English and Director of Athletics, Hamilton Institute, 1906-1908; Graduate student of English, Columbia University, 1907; Director of Athletics and Instructor in Dramatics, Pomona College, 1908-1916; Director of Athletics and Instructor in English and Dramatics, Occidental College, 1916-1917, 1919-1921. California Institute, 1921-

515 Manzanita Avenue, Sierra Madre

MORGAN WARD, PH.D.

Associate Professor of Mathematics

A.B., University of California, 1924; Ph.D., California Institute of Technology, 1928. Assistant in Mathematics, California Institute, 1925-1926; Teaching Fellow. 1926-1928; Research Fellow, 1928-1929; Assistant Professor, 1929-1935; Associate Professor, 1935-

241 South Holliston Avenue

LUTHER EWING WEAR, PH.D.

Associate Professor of Mathematics

A.B., Cumberland University, 1902; Ph.D., Johns Hopkins University, 1913. Instructor in Mathematics, University of Washington, 1913-1918. Calfornia Institute, 1918.

2247 Lambert Drive

DON M. YOST, PH.D.

Associate Professor of Inorganic Chemistry

B.S., University of California, 1923; Ph.D., California Institute of Technology, 1926. Instructor in Chemistry, University of Utah, 1923-1924; duPont Fellow, California Institute, 1924-1925; Teaching Fellow, 1925-1926; Research Fellow, 1926-1927; Instructor, 1927-1929; Fellow of the International Education Board, 1928-1929; Assistant Professor, 1929-1935; Associate Professor, 1935-

1971 Rose Villa Street

FRITZ ZWICKY, PH.D.

Associate Professor of Theoretical Physics

Graduate, Eidg. Technische Hochschule, Zurich, 1920; Ph.D., 1922. Assistant in Physics, Eidg. Technische Hochschule, 1921-1925. Fellow of International Education Board, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-

1260 Loraine Road, San Marino

CARL DAVID ANDERSON, PH.D. Assistant Professor of Physics

B.S., California Institute of Technology, 1927; Ph.D., 1930. Assistant in Physics, California Institute, 1927-1930; Research Fellow, 1930-1933; Assistant Professor, 1933-

520 South Lake Avenue

RICHARD MCLEAN BADGER, PH.D.

Assistant Professor of Chemistry

B.S., California Institute of Technology, 1921; Ph.D., 1924. International Research Fellow in Chemistry, 1928-1929. Assistant in Chemistry, California Institute, 1921-1922; Teaching Fellow, 1922-1924; Research Fellow, 1924-1928; Assistant Professor, 1929-

215 Highland Place, Monrovia

ARNOLD ORVILLE BECKMAN, PH.D.

Assistant Professor of Chemistry

B.S., University of Illinois, 1922; M.S., 1923; Ph.D., California Institute of Technology, 1928. Research Associate, Bell Telephone Laboratories, 1924-1926. Teaching Fellow, California Institute, 1923-1924; 1926-1928; Instructor, 1928-1929; Assistant Professor, 1929-

1970 Crescent Drive, Altadena

WILLIAM NOEL BIRCHBY, M.A. Assistant Professor of Mathematics Assistant Registrar

A.B., Hope College, 1899; M.A., Colorado College, 1905. Instructor, Colorado College, 1905 and 1907; Instructor in Physics, University of Southern California, summer session, 1916. Instructor, California Institute, 1918-1931; Assistant Professor, 1931-251 South Catalina Avenue

FRED J. CONVERSE, B.S.

Assistant Professor of Civil Engineering

 B.S. in Mechanical Engineering, University of Rochester, 1914. Appraisal Engineer, Cleveland Electric Illuminating Company, Cleveland, Ohio, 1914-1915. Student Engineer, General Electric Company, Lynn, Massachusetts, 1915-1916. Instructor in Applied Mechanics, University of Rochester, 1916-1917. Engineer in Charge of Materials Tests, General Laboratories, Bureau of Aircraft Production. U. S. A., 1917-1918. Assistant Production Engineer, Gleason Gear Works, Rochester, New York, 1919. Designer, Bureau of Power and Light, Los Angeles City, 1920. Instructor, California Institute, 1921-1933; Assistant Professor, 1933-

THEODOSIUS DOBZHANSKY

Assistant Professor of Genetics

Diploma, University of Kiev, 1921. Assistant in Zoology, Polytechnic Institute of Kiev, 1921-1924. Lecturer in Genetics, University of Leningrad, 1924-1927. Research Fellow, Bureau of Genetics, Russian Academy of Sciences, 1925-1927. Research Fellow in Biology of the International Education Board, Columbia University, 1927-1928; California Institute, 1928-1929; Assistant Professor, 1929-

360 South Wilson Avenue

HARVEY EAGLESON, PH.D.

Assistant Professor of English Language and Literature Resident Associate in Blacker House

B.A., Reed College, 1920; M.A., Leland Stanford University, 1922; Ph.D., Princeton University, 1928. Instructor in English, University of Texas, 1922-1926. California Institute, 1928-

Blacker House

ROBERT EMERSON. PH.D.

Assistant Professor of Biophysics

 A.B., Harvard University, 1925; Ph.D., University of Berlin, 1927. National Research Fellow in Biology, Harvard University, 1927-1929. Instructor in Biophysics, Harvard University, 1929-1930. California Institute, 1930 1175 Woodbury Road

STERLING H. EMERSON, PH.D. Assistant Professor of Genetics

 B.S., Cornell University, 1922; M.S., University of Michigan, 1924; Ph.D., 1928. Instructor in Botany, University of Michigan, 1924-1928. Cali-fornia Institute, 1928 391 South Wilson Avenue 391 South Wilson Avenue

CLYDE K. EMERY, M.D.

Assistant Professor of X-Ray Therapy

P.A., University of California, 1923; L.R.C.P., London, 1928, M.R.C.S., England, 1928. California Institute, 1931-3111 Waverly Drive, Los Angeles

PHILIP SHEARER FOGG, M.B.A. Assistant Professor of Business Economics Registrar

A.B., Stanford University, 1925; M.B.A., Harvard University, 1929. California Institute, 1930-

1281 North Chester Avenue

HORACE J. FRASER, PH.D.

Assistant Professor of Mineralogy and Mineragraphy

B.Sc., University of Manitoba, 1925; M.Sc., 1927; M.A., Harvard University, 1928; Ph.D., 1930. Assistant in Geology, University of Manitoba, 1925-1927; University of Manitoba Travelling Fellow, 1927-1928; Instructor in Economic Geology, Harvard University, 1928-1930; National Research Fellow, 1930-1931; Research Associate in Geology, Harvard University, 1931-1932; Geologist, International Nickel Company of Canada, Ltd., 1932-1935. California Institute, 1935-2050 Neurona, Augusta

2059 Navarro Avenue

HUGH MARTIN HUFFMAN, PH.D.

Assistant Professor of Biochemistry

A.B., Leland Stanford Junior University, 1925; M.A., 1926; Ph.D., 1928. Instructor in Chemistry, San Jose Teachers College, 1925-1927; Fellow of the American Petroleum Institute, Leland Stanford Junior Univer-sity, 1927-1931. California Institute, 1931-

3280 Mount Curve Avenue, Altadena

WILLIAM HUSE, M.A.

Assistant Professor of English Language and Literature

A.B., Stanford University, 1921; M.A., Princeton University, 1928. Instruc-tor in English, Washington University, 1921-1923; Instructor in En-glish, Princeton University, 1923-1924; Assistant Professor of English, University of Kansas, 1927-1929. California Institute, 1929-

1131 Lura Street

ROBERT TALBOT KNAPP, PH.D.

Assistant Professor of Mechanical Engineering

 B.S., Massachusetts Institute of Technology, 1920; Ph.D., California Institute of Technology, 1929. Designer with C. M. Gay & Son, Refrigerating Engineers, 1920-1921; Consulting Engineer, Riverside Cement Company, 1927-1929; American Society of Mechanical Engineers Freeman Scholar in Europe, 1929-1930. Instructor, California Institute, 1922-1930; Assistant Professor, 1930-2526 North Roosevelt Avenue 2526 North Roosevelt Avenue

IRVING PARKHURST KRICK, PH.D.

Assistant Professor of Meteorology

A.B., University of California, 1928; M.S., California Institute of Technol-ogy, 1933; Ph.D., 1934. Teaching Fellow, California Institute, 1932-33; Instructor, 1933-1935; Assistant Professor, 1935-

2174 San Pasqual Street

FREDERICK CHARLES LINDVALL, PH.D.

Assistant Professor of Electrical Engineering

B.S. University of Illinois, 1924; Ph.D. California Institute of Technology, 1928. Electrical Engineering Department, Los Angeles Railway Corp-oration, 1924-1925; Engineering General Department, General Electric Company, Schenectady, 1928-1930. Assistant in Electrical Engineering, California Institute, 1925-1927; Teaching Fellow, 1927-1928; Instructor, 1930-1931; Assistant Professor, 1931-1860 Allen Drive, Altadena

1860 Allen Drive, Altadena

GEORGE EBER MACGINITIE, M.A.

Assistant Professor of Biology

A.B., Fresno State College, 1925; M.A., Stanford University, 1928. In-structor in Biology, Fresno State College, 1925-1928; Instructor in Zoology, Hopkins Marine Station of Stanford University, 1928-1929; Assistant Professor of Zoology, 1929-1932. California Institute, 1932-

Corona del Mar

FRANCIS WILLIAM MAXSTADT, PH.D.

Assistant Professor of Electrical Engineering

M.E., Cornell University, 1916; Certificate of E.E., 1916; M.S., California Institute of Technology, 1925; Ph.D., 1931. Draftsman and Designer, Otis Elevator Company, 1916-1917. Assistant in the Electrical Research Division, Interborough Rapid Transit Company, 1917-1919. Assistant in the Thomas A. Edison Laboratories, 1919. Instructor, California Insti-tute, 1919-1933; Assistant Professor, 1933-

1666 North Grand Oaks Avenue, Altadena

ARTHUR EMMONS RAYMOND, M.S.

Assistant Professor of Aeronautics

S.B., Harvard University, 1920; M.S. in Aeronautics, Massachusetts Insti-tute of Technology, 1921. Assistant Chief Engineer, Douglas Aircraft Co., Santa Monica, 1925-1935; Chief Engineer, 1935-. California Institute, 1929-

554 Moreno Avenue, Santa Monica

ROGER STANTON, PH.D.

Assistant Professor of English Language and Literature

B.S., ., Colgate University, 1920; M.A., Princeton University, 1924; Ph.D., 1931. Instructor in English, Colorado College, 1924-1925. Instructor, California Institute, 1925-1931; Assistant Professor, 1931-

1672 Poppy Peak Drive

RICHARD STEWART-HARRISON, M.D.

Assistant Professor of X-Ray Therapy

B.A. (Oxon), 1927; B.M., B.Ch. (Oxon), 1929; M.R.C.S. and L.R.C.P., 1930;
 M.D., University of Zurich, 1932; D.M.R., University of London, 1933.
 Assistant Radiologist, Zurich University, 1930-1934; Assistant Radiologist, Fondation Curie, 1935. California Institute, 1935.

Athenæum

ERNEST HAYWOOD SWIFT, PH.D.

Assistant Professor of Analytical Chemistry

B.S. in Chemistry, University of Virginia, 1918; M.S., California Institute of Technology, 1920; Ph.D., 1924. Teaching Fellow, California Insti-tute, 1919-1920; Instructor, 1920-1928; Assistant Professor, 1928-

3140 East California Street

RAY EDWARD UNTEREINER, J.D., PH.D.

Assistant Professor of Economics and History

A.B., University of Redlands, 1920; A.M., Harvard University, 1921; J.D., Mayo College of Laws, 1925; Ph.D., Northwestern University, 1932. Instructor in Economics, Harvard University, 1921-1923; Professor of Public Speaking, Huron College, 1923-1924; Instructor in Economics and Social Science, Joliet Junior College, 1924-1925. Member of Cali-fornia Bar. Instructor, California Institute, 1925-1930; Assistant Pro-fessor, 1930-

1089 San Pasqual Street

CORNELIS A. G. WIERSMA, PH.D.

Assistant Professor of Physiology

B.A., University of Leiden, 1926; M.A., University of Utrecht, 1929; Ph.D., 1933. Assistant in Comparative Physiology, University of Utrecht, 1929, 1931; Dondersfonds Research Fellow, 1930-1931; Chief Assistant Medical Physiology, University of Utrecht, 1932-1934. California Institute, 1934-

.

140 South Wilson Avenue

EDWARD DUNSTER KREMERS, M.D. Consulting Physician

o., University of Michigan, 1903; Graduate, Army Medical School, 1910. Lt. Col. U. S. Army, Retired. California Institute, 1930-M.D.

2315 Mar Vista Avenue, Altadena

GEORGE W. BEADLE, PH.D. Instructor in Biology

·-----

B.Sc., University of Nebraska, 1926; M.Sc., 1927; Ph.D., Cornell University, 1930. Assistant in Agronomy, Cornell University, 1926-27; Experimen-talist in Plant Breeding, 1928-30. Research Fellow, California Institute, 1930-1935; Instructor, 1935-

863 North Sunset Boulevard, Arcadia

STAFF OF INSTRUCTION AND RESEARCH

LAWRENCE OLIN BROCKWAY, PH.D. Senior Fellow in Chemical Research

B.S., University of Nebraska, 1929; M.S., 1930; Ph.D., California Institute of Technology, 1933. Assistant and Teaching Fellow, California Institute, 1930-1933; Research Fellow, 1933-1935; Senior Fellow in Research, 1935-

147 South Berkeley Avenue

DONALD SHERMAN CLARK, PH.D. Instructor in Mechanical Engineering

B.S., California Institute of Technology, 1929; M.S., 1930; Ph.D., 1934. Assistant and Teaching Fellow, California Institute, 1929-1934; Instructor, 1934-

Athenæum

ANTHONIE VAN HARREVELD, M.D.

Instructor in Physiology

B.A., Amsterdam University, 1925; M.A., 1928; M.D., 1929. Assistant in Physiology, Amsterdam University, 1926-1932; Chief Assistant in Physiology, Utrecht University, 1932-1934. Research Assistant, California Institute, 1934-1935; Instructor, 1935-

702 South Oak Knoll Avenue

LOUIS WINCHESTER JONES, A.B.

Instructor in English Language and Literature

A.B., Princeton University, 1922. California Institute, 1925-

351 California Terrace

WALDEMAR ALEXANDER KLIKOFF, B.S.

Instructor in Aeronautics

B.S. in Naval Architecture and Marine Engineering, Massachusetts Institute of Technology, 1923. Structural and Aerodynamic Analysis Engineer with several aircraft manufacturers (now with the Douglas Aircraft Co., Inc.), 1924-1934; Lecturer in Aerostatics (part time), University of Detroit, 1930-1932. California Institute, 1934-

1065 Princeton Street, Santa Monica

RUDOLPH M. LANGER, PH.D.

Senior Fellow in Astrophysical Research

B.S., College of the City of New York, 1920; M.A., Columbia University, 1921; Ph.D., California Institute of Technology, 1927. Assistant Physicist, Naval Research Laboratory, 1926-1927; National Research Fellow in Physics, Bureau of Standards, 1927-1929; University of Berlin, 1929-1930; Assistant Professor of Physics, Massachusetts Institute of Technology, 1930-1931; Professorial Lecturer in Physics, University of Minnesota, 1931-1932. Research Fellow in Physics, California Institute, 1932-35; Senior Fellow in Astrophysical Research, 1935-

235 Fowler Street, Playa del Rey

JOHN HAVILAND MAXSON, PH.D.

Instructor in Geology

B.S., California Institute, 1927; M.S., 1928; Ph.D., 1931. Assistant in Geology, California Institute, 1927-1928; Teaching Fellow, 1928-1931; Instructor, 1931-

653 South Oak Knoll Avenue

HAROLD Z. MUSSELMAN, A.B.

Assistant Director of Physical Education and Manager of Athletics

A.B., Cornell College, 1920. Instructor in Science and Athletic Director. Sterling (Illinois) High School, 1920-1921. Instructor, California Institute, 1921-1935; Assistant Director, 1935-

824 East California Street

HENRY VICTOR NEHER, PH.D. Instructor in Physics

B.A., Pomona College, 1926; Ph.D., California Institute of Technology, 1931. Assistant in Physics, California Institute, 1928-1931; Research Fellow, 1931-1933; Instructor, 1933-

1773 Oakdale Street

BRUCE HORNBROOK SAGE, PH.D.

Senior Fellow in Chemical Research

B.S., New Mexico State College, 1929; M.S., California Institute of Technology, 1931; Ph.D., 1934. Teaching Fellow, California Institute, 1930-1934; Research Fellow, 1934-1935; Senior Fellow, 1935-

1567 North Holliston Avenue

ERNEST EDWIN SECHLER, PH.D. Instructor in Engineering Drawing

B.S., California Institute, 1928; M.S., 1929; Ph.D., 1933. Assistant in Engineering, California Institute, 1928-1930; Instructor, 1930-

2199 Cooley Place

FRANCES HALSEY SPINING Librarian

California Institute, 1914-

1067 North Catalina Avenue

HERMAN J. STOEVER, PH.D.

Instructor in Mechanical Engineering

B.S., Purdue University, 1928; M.S., University of Illinois, 1930; Ph.D., 1934. Research Graduate Assistant, University of Illinois, 1928-1930. Research Engineer, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pennsylvania, 1930-1932. Teaching Fellow, University of Illinois, 1932-1934. Research Engineer, Linde Air Products Company, Buffalo, New York, 1934-1935. Instructor, California Institute, 1935-

40 South Wilson Avenue

JOHN DONOVAN STRONG, PH.D.

Senior Fellow in Astrophysical Research

A.B., Kansas University, 1926; M.S., University of Michigan, 1928; Ph.D., 1930. National Research Fellow in Physics, California Institute, 1930-1932; Research Fellow in Astrophysics, 1932-1935; Senior Fellow in Research, 1935-

382 East California Street

JAMES HOLMES STURDIVANT, PH.D.

Senior Fellow in Chemical Research

B.A., University of Texas, 1926; M.A., 1927; Ph.D., California Institute of Technology, 1930. Instructor in Mathematics, University of Texas, 1926-1927. Teaching Fellow, California Institute, 1927-1930; Research Fellow, 1930-1935; Senior Fellow in Research, 1935-

Athenæum

KENNETH VIVIAN THIMANN, PH.D.

Instructor in Bacteriology

 B.Sc., University of London (Imperial College), 1924; A.R.C.S., 1924; Ph.D., 1928. Frank Hatton Prizeman in Chemistry, 1924. Demonstrator in Bacteriology, London University, 1925-1927. Beit Memorial Research Fellow in Biochemistry, 1927-1929. California Institute, 1980-355 East Las Flores Drive, Altadena

ALBERT TYLER, PH.D.

Instructor in Embryology

A.B., Columbia University, 1926; A.M., 1927; Ph.D., California Institute of Technology, 1929. National Research Fellow in Biology in Berlin and Naples, 1932-1933; California Institute, 1928-

665 South Mentor Avenue

GEORGE WILLARD WHELAND, PH.D. Senior Fellow in Chemical Research

B.S., Dartmouth College, 1928; A.M., Harvard University, 1929; Ph.D., 1932. Research Fellow, California Institute, 1932-1935; Senior Fellow in Research, 1935-

306 South El Molino Avenue

NATHANIEL W. WILCOX, A.B. Instructor in Engineering Drawing

Instructor in Bugineering Drawing

A.B., Harvard University, 1917. California Institute, 1932-

156 South El Molino Avenue

RESEARCH FELLOWS

HANS GUSTAV EMIL BAUER, D.PHIL.

International Research Fellow in Biology of the Rockefeller Foundation

D.Phil., University of Göttingen, 1931. Research Assistant, Kaiser Wilhelm Institut für Biologie, Berlin-Dahlem, 1932-. California Institute, 1935-1148 Constance Street

CALIFORNIA INSTITUTE OF TECHNOLOGY

Tom Wilkerson Bonner, Ph.D.

National Research Fellow in Physics

B.S., Southern Methodist University, 1931; M.A., The Rice Institute, 1932; Ph.D., 1934. California Institute, 1934-

Athenæum

LEE REED BRANTLEY, PH.D.

Research Fellow in Physics

A.B., University of California at Los Angeles, 1927; M.S., California Institute of Technology, 1929; Ph.D., 1930. Instructor in Chemistry and Physics, Occidental College, 1930-. California Institute, 1935-

2135 Fair Park Avenue, Los Angeles

CHARLES DUBOIS CORYELL, PH.D. Research Fellow in Chemistry

B.S., California Institute of Technology, 1932; Ph.D., 1935. California Institute, 1932-

2247 Prospect Street, Wilmar

GOTTFRIED DÄTWYLER, DR. ING.

Research Fellow in Aeronautics

Mech. Eng., Eidgenössische Technische Hochschule, Zürich, 1929; Dr. Ing., 1934. California Institute, 1934-

1447 East Las Lunas Street

MAURICE DONNELLY, PH.D.

Research Fellow in Geology and in Hydraulics

(Soil Conservation Service, Department of Agriculture)

E.M., Colorado School of Mines, 1929; M.S., California Institute of Technology, 1933; Ph.D., 1935. California Institute, 1930-

406 South Chester Avenue

FRANK GLASS DUNNINGTON, PH.D.

Research Fellow in Physics

B.S., University of California, 1929; Ph.D., 1932. California Institute, 1932-338 Adena Street

LUDO KARL FREVEL, PH.D. National Research Fellow in Chemistry

Ph.D., Johns Hopkins University, 1934. California Institute, 1934-

671 South Catalina Avenue

ENRIQUE GAVIOLA, PH.D.

Fellow in Physics of the John Simon Guggenheim Memorial Foundation

Bachiller, Colegio Nacional de Mendoza (Argentina), 1916; Agrimensor, University of La Plata, 1921; Ph.D., University of Berlin, 1926; Fellow of the International Education Board of Johns Hopkins University, 1927; Assistant Physicist of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, 1928; Substitute Professor of Theoretical Physics, La Plata University, 1929; Professor of Physical Chemistry and of Theoretical Physics, Buenos Aires University, 1930-; California Institute, 1934-

1728¹/₂ Oxley Street, South Pasadena

LINDSAY HELMHOLZ, PH.D.

National Research Fellow in Chemistry

Ph.D., Johns Hopkins University, 1933. California Institute, 1933-

1659 Oakdale Street

GILBERT WILLIAM KING, PH.D.

National Research Fellow in Physics

S.B., Massachusetts Institute of Technology, 1933; Ph.D., 1935. California Institute, 1935-

Athenæum

PHILIP TRUMAN IVES, M.A.

Research Fellow in Biology

B.A., Amherst College, 1932; M.A., 1934; Rufus B. Kellogg University Fellow of Amherst College at the California Institute, 1934-2924 South Monter Accounts

384 South Mentor Avenue

HYWEL OLIVER JENKINS, PH.D., D.PHIL. Commonwealth Fund Fellow in Chemistry

B.Sc., University of Wales, 1928; Ph.D., 1932; D.Phil., University of Oxford, 1934. California Institute, 1934-Athenæum

JOSEF JEROME JOHNSON, PH.D. Research Fellow in Astrophysics

B.S., California Institute of Technology, 1930; M.S., Ohio Weslevan University, 1932; Ph.D., California Institute of Technology, 1935. California Institute, 1932-

596 South Greenwood Avenue

CHAO-YING MENG, M.S.

Fellow in Physics of the Rockefeller Foundation

B.S., Yenching University, 1928; M.S., 1931. Instructor in Physics, Yenching University, 1931-. California Institute, 1933-

344 South Catalina Avenue

RAYMOND ALFRED PETERSON, PH.D.

Research Fellow in Geology

B.S., California Institute of Technology, 1931; Ph.D., 1935. California Institute, 1931-

Athenæum

JACK HENRY SHERMAN, PH.D.

Research Fellow in Chemistry

B.S., University of California, 1929; Ph.D., California Institute of Technology, 1932. California Institute, 1929-266 South Chester Avenue

HAMPTON SMITH, PH.D.

Research Fellow in Geology

B.S., California Institute of Technology, 1928; Ph.D., 1934. California Institute, 1928-

653 South Oak Knoll Avenue

JOSHUA LAWRENCE SOSKE, PH.D.

Research Fellow in Geology

G.E., Colorado School of Mines, 1929; M.S., California Institute of Technology, 1932; Ph.D., 1935. California Institute, 1931-1190 North Michigan Avenue

HANNS HEINRICH VON STENGEL

International Exchange Fellow in Physics

Technische Hochschule, Muenchen, 1931-1935; Technische Hochschule, Danzig, 1933. California Institute, 1935-

Athenæum

DANIEL DWIGHT TAYLOR, PH.D.

Research Fellow in Physics

A.B., Colorado College, 1924; Ph.D., California Institute of Technology, 1933. California Institute, 1924-1843. Mendocino Lane

1843 Mendocino Lane

ANDREW DAVID THACKERAY, B.A.

Commonwealth Fund Fellow in Astrophysics

B.A., Cambridge University, 1932. California Institute, 1934-430 South San Marino Avenue

VITO AUGUST VANONI, M.S.

Research Fellow in Hydraulics

(Soil Conservation Service, Department of Agriculture)

B.S., California Institute of Technology, 1926; M.S., 1932. Engineer with McClintic Marshall Corp., 1926-1928, 1931-1932; Engineer with American Bridge Company, 1928-1930. California Institute, 1932-

169 South Greenwood Avenue

FRANK LESLIE WATTENDORF, PH.D.

Research Fellow in Aeronautics

B.A., Harvard University, 1926; M.A., Massachusetts Institute of Technology, 1928; Ph.D., California Institute of Technology, 1933. California Institute, 1930- Non-Resident Club

SIDNEY WEINBAUM, PH.D.

Research Fellow in Chemistry

B.S., California Institute of Technology, 1924; Ph.D., 1933. California Institute, 1929-

167 South Wilson Avenue

34

STAFF OF INSTRUCTION AND RESEARCH

CHESTER EUGENE WILSON, PH.D.

Research Fellow in Chemistry

B.S., California Institute of Technology, 1932; M.S., 1933; Ph.D., 1935. California Institute, 1932-

11101 Hortense Street, North Hollywood

RESEARCH ASSISTANTS GEORGE HAROLD ANDERSON, PH.D. Curator in Petrology

 A.B., Stanford University, 1917; A.M., 1920; Ph.D., California Institute of Technology, 1933. Instructor in Geology, University of Colorado, 1928-1929; Teaching Fellow in Geology, California Institute, 1929-1933; Research Fellow, 1933-1934; Curator, 1934-

2021 Santa Anita Avenue, Altadena

SIMON HARVEY BAUER, PH.D.

Research Assistant in Chemistry

B.S., University of Chicago, 1931; Ph.D., 1935. California Institute, 1935-Athenæum

> WILLIAM RAYMOND BERGREN Research Assistant in Biology Conductor of the Orchestra

B.S., California Institute of Technology, 1932. California Institute, 1933-1056 East Walnut Street

FRANCIS DASHWOOD BODE, PH.D.

Assistant Curator in Vertebrate Paleontology

B.S., California Institute of Technology, 1930; M.S., 1931; Ph.D., 1934. Assistant and Teaching Fellow in Geology, California Institute, 1930-1934. Assistant Curator, 1934-45 Fast Leurel Avenue Sierre Medre

45 East Laurel Avenue, Sierra Madre

JAMES FREDERICK BONNER, PH.D. Research Assistant in Biology

A.B., University of Utah, 1931; Ph.D., California Institute of Technology, 1934. California Institute, 1935-290 South Michigan Avenue

WILLIAM HAROLD BOWEN, M.S.

Research Assistant in Aeronautics

B.S., University of California, 1928; M.S., California Institute, 1932. California Institute, 1932-1147 Constance Street

CALIFORNIA INSTITUTE OF TECHNOLOGY

NEPHI ALBERT CHRISTENSEN, M.S. Research Assistant in Hydraulics*

 B.S., Brigham Young University, 1925; B.S.C.E., University of Wisconsin, 1928; M.S., California Institute of Technology, 1934. California Institute, 1934 LOSE Fact Del Mar Street

1035 East Del Mar Street

SIDNEY WALTER FOX, B.A.

Research Assistant in Biology

B.A., University of California at Los Angeles, 1933. California Institute, 1935-

3317 Griffith Park Boulevard, Los Angeles

EUSTACE L. FURLONG Curator in Vertebrate Paleontology

Assistant in Paleontology, 1903-1910; Curator of Vertebrate Paleontology, University of California, 1915-1927. California Institute, 1927-270 South Roosevelt Avenue

LOWELL FORREST GREEN, B.S.

Research Assistant in Biology

B.S., California Institute of Technology, 1931. California Institute, 1932-406 South Chester Avenue

> CECIL EDWARD PRUITT JEFFREYS, PH.D. Research Assistant in Biology

B.A., University of Texas, 1925; M.A., 1927; Ph.D., California Institute of Technology, 1931. California Institute, 1928-2311 Oakdale Street

> FRED DELBRIDGE KNOBLOCK, M.S. Research Assistant in Aeronautics

B.Sc., University of Michigan, 1926; M.S., 1927. California Institute, 1935-225 South Bonnic Avenue

LAVERNE DAVIDSON LEEPER, M.S.

Research Assistant in Hydraulics*

B.S., California Institute of Technology, 1931; M.S., 1932. California Institute, 1935-519 South Oakland Avenue

LEO M. LEVI, M.D.

Research Assistant in X-Ray Therapy

A.B., Ohio State University, 1923; M.D., Jefferson Medical College, 1927. California Institute, 1934-4833 Fountain Avenue, Los Angeles

/

*Soil Conservation Service, Department of Agriculture.

36
STAFF OF INSTRUCTION AND RESEARCH

GEORGE HEINEMAN MARMONT, B.S. Research Assistant in Biology

B.S., California Institute of Technology, 1934. California Institute, 1935-Athenæum

SETH HENRY NEDDERMEYER, PH.D. Research Assistant in Physics

A.B., Stanford University, 1929; Ph.D., California Institute of Technology, 1935. California Institute, 1935-951 East California Street

ROBERT MARTIN OAKS, B.S.

Research Assistant in Hydraulics*

B.S., California Institute of Technology, 1931. California Institute, 1935-572 North El Molino Avenue

GEORGE HERMAN OTTO, S.B.

Research Assistant in Hydraulics*

S.B., University of Chicago, 1931. California Institute, 1935-834 East California Street

WILLIS PARKINSON POPENOE, B.S.

Curator in Invertebrate Paleontology

B.S., George Washington University, 1930; California Institute, 1931-466 South Hudson Avenue

HAROLD FRANK RICHARDS, B.S.

Research Assistant in Hydraulics*

B.S., California Institute of Technology, 1926. California Institute, 1935-771 East Fourteenth Street, Los Angeles

JOHN L. RIDGWAY

Scientific Illustrator in Vertebrate Paleontology

Chief Illustrator, United States Geological Survey, 1898-1920; Artist, Carnegie Institution of Washington, 1910-. California Institute, 1929-635 North Pacific Avenue, Glendale

> MARSTON CLEAVES SARGENT, PH.D. Research Assistant in Biology

A.B., Harvard University, 1928; Ph.D., California Institute of Technology, 1934. California Institute, 1930-

866 North Chester Avenue

*Soil Conservation Service, Department of Agriculture.

CHARLES LEWIS SCHNEIDER, B.S.

Research Assistant in Biology

B.S., California Institute of Technology, 1934. California Institute, 1935-1007 North Brand Boulevard, Glendale

> JOHN ELLIOTT SHERBORNE, B.S. Research Assistant in Chemistry**

B.S., California Institute of Technology, 1934. California Institute, 1935-145 South Catalina Avenue

> JOHANNES VAN OVERBEEK, PH.D. Research Assistant in Biology

B.Sc., University of Leyden, 1928; M.S., University of Utrecht, 1932; Ph.D., 1933. Assistant in Botany, University of Utrecht, 1933-1934. California Institute, 1934-

1787 Orangewood Street

DONALD C. WEBSTER, B.S.

Research Assistant in Chemistry**

B.S., California Institute of Technology, 1935. California Institute, 1935-1846 North Van Ness Avenue, Hollywood

MERIT PENNIMAN WHITE, PH.D.

Research Assistant in Hydraulics*

A.B. ., Dartmouth College, 1930; C.E., 1931; M.S., California Institute of Technology, 1932; Ph.D., 1935. California Institute, 1931-336 Sacramento Street

NATHAN DAVIS WHITMAN, JR., M.S.

Research Assistant in Hydraulics*

B.S., California Institute of Technology, 1930; M.S., 1932. California Institute, 1935-643 South Oak Knoll Avenue

FLOYD L. HANES, D.O. Physical Trainer

D.O., College of Osteopathic Physicians and Surgeons, Los Angeles, 1921. California Institute, 1923-

2115 Layton Avenue

AUDRE L. STONG, M.S.

Director of Band and Glee Club

B.S., University of Southern California, 1932; M.S., 1934. California Institute, 1931-

80 North Bonnie Avenue

*Soil Conservation Service, Department of Agriculture. **American Petroleum Institute.

.

STAFF OF INSTRUCTION AND RESEARCH

TEACHING FELLOWS AND GRADUATE ASSISTANTS

CHARLES KIRKWOOD ALEXANDER ¹ Physics Resident Associate in Dabney House. A.B., Oberlin College, '32.
THOMAS FOXEN ANDERSON
HUBERT ANDREW ARNOLD
SIDNEY FRANCIS BAMBERGER . Physical Education and Civil Engineering B.S., California Institute, '33.
JOHN YOUNGS BEACH ³
ROBERT ADOLPH BECKER
DAVID FULMER BENDER
RAYMOND CHARLES BINDER Mechanical Engineering B.S., Massachusetts Institute of Technology, '30; M.S., California Insti- tute, '33.
ROBERT DEVORE BOCHE Biology B.S., California Institute, '34.
EUGENE BOLLAY Meteorology B.S., Northwestern University, '35.
WILLIAM BOLLAY Aeronautics B.S., Northwestern University, '33; M.S., California Institute, '34.
VERNON LEROY BOLLMAN ⁵ Physics B.S., University of Nebraska, '31; M.S., '33.
EDMUND BORYS
RICHARD THEOBOLD BRICE ¹
THOMAS EVERETT BROWNE, JR Electrical Engineering B.S., North Carolina State College of Agriculture and Engineering, '28; M.S., University of Pittsburgh, '33.
WILSON MARCUS BRUBAKER ² Physics A.B., Miami University, '32.
EUGENE MITTELL BRUNNER ¹ Mathematics B.S., California Institute, '33; M.S., '34.
¹ Henry Laws Fellow. ² High Potential Radiation Research Fund. ³ Caroline W. Dobbins Fellow. ⁶ Norman Bridge Fellow.

89

ROBERT PEARNE BRYSON
ROLAND ANTHONY BUDENHOLZER Mechanical Engineering B.S., New Mexico State College of Agriculture and Mechanic Arts, '35.
ALEXANDER CRANE CHARTERS, JR Aeronautics B.S., California Institute, '34.
MILFORD CARLSON CHILDERS Aeronautics B.S., California Institute, '34; M.S., '35.
CLYDE CUTHBERTSON CHIVENS Mechanical Engineering B.S., California Institute, '35.
CLARENCE WILLIAM CLANCY Biology B.S., University of Illinois, '30; M.S., '32.
WILLIAM GILBERT CLARK Biology B.A., University of Texas, '31.
ROBERT ALMA CLARKE ³
FRANCIS HETTINGER CLAUSER Aeronautics B.S., California Institute, '34; M.S., '35.
MILTON URE CLAUSER Aeronautics B.S., California Institute, '34; M.S., '35.
WILLIAM MAURICE COGEN
KENNETH CARL CRUMRINE ¹
CHARLES ALEXANDER DAWSON, JR
THOMAS JAY DEAHL ³
LEWIS A. DELSASSO ²
NORMAN BRANSON DEWEES Engineering Drawing B.S., California Institute, '35.
CLARENCE LINCOLN DUNN
VICTOR ELCONIN ¹
¹ Henry Laws Fellow.

²High Potential Radiation Research Fund. ³Caroline W. Dobbins Fellow.

STAFF OF INSTRUCTION AND RESEARCH

EUGENE HENDERSON EXSTER ¹ Chemistry B.Ch., University of Minnesota, '35.
PAUL CHARLES FINE ⁴ Physics B.A., University of Oklahoma, '35.
MARK GARDNER FOSTER
WILLIAM ALFRED FOWLER ² Physics B.Eng.Physics, Ohio State University, '33.
JAMES MAY Fox
ROBERT BRAMAN FREEMAN Mechanical Engineering B.S., California Institute, '32; M.S., '33.
CLIFFORD SYMES GARNER
VERNON ARTHUR CHARLES GEVECKER Civil Engineering B.S.C.E., Missouri School of Mines, '31.
EMERSON WARD GREEN Chemistry B.S., California Institute, '35.
RAYMOND HOWARD GRIEST Electrical Engineering B.S., California Institute, '32; M.S., '33.
THOMAS WILLIAM GRIFFITHS
NEWMAN ARNOLD HALL ³ Mathematics A.B., Marietta College, '34.
DAVID HARKER
PAUL FREDERICK HAWLEY Electrical Engineering B.S., University of Arizona, '32; M.S., California Institute, '33.
SHERWOOD KIMBALL HAVNES Physics A.B., Williams College, '32.
ARTHUR HEMMENDINGER ³
IVAR EDMUND HIGHBERG ³ Mathematics B.A., Whitman College, '32; A.M., '33.
WALTER LAVERN HOWLAND Aeronautics B.S., California Institute, '34; M.S., '35.
¹ Henry Laws Fellow. High Potential Radiation Research Fund.

.

[°]Caroline W. Dobbins Fellow. ⁴Charles A. Coffin Fellow.

Blacker Fellow.

WILLIAM BURDETTE MCLEAN ³ Physics B.S., California Institute, '35.
JAMES WILSON MCRAE Electrical Engineering Resident Associate in Ricketts House. B.App.Sc., University of British Columbia, '33; M.S., California Insti-
tute, '34. WILLIAM ALVIN MERSMAN ³ Mathematics B.S., California Institute, '33; M.S., '34.
HAROLD DAVID MICHENER Biology B.S., California Institute, '34.
FRANK OPPENHEIMER
ELBURT FRANKLIN OSBORN ⁶
DARRELL WAYNE OSBORNE
CARL F. J. OVERHAGE Languages B.S., California Institute, '31; M.S., '34.
KENNETH JAMES PALMER
SIMON PASTERNACK
Edwin Woolman Paxson ¹
WILLIAM HAYWARD PICKERING Physics B.S., California Institute, '32; M.S., '33.
JOHN ROBINSON PIERCE Electrical Engineering B.S., California Institute, '33; M.S., '34.
LOUIS ALBERT PIPES Electrical Engineering B.S., California Institute, '33; M.S., '34.
EGOR PAUL POPOFF Applied Mechanics B.S., University of California, '33; M.S., Massachusetts Institute of Technology, '34.
WARREN THOMAS POTTER, JR Physical Education and B.S., California Institute, '35. Electrical Engineering
DONALD FREDERICK POULSON Biology B.S., California Institute, '33.

43

CALIFORNIA INSTITUTE OF TECHNOLOGY

WILLARD DICKISON PYE
LOUIS TELEMACUS RADER Electrical and Civil Engineering B.A.Sc., University of British Columbia, '33; M.S., California Institute, '35.
SIMON RAMO Electrical Engineering B.S., University of Utah, '33.
JOHN SARGENT RINEHART
WILLIAM CURTIS ROCKEFELLER Meteorology Resident Associate in Fleming House. B.S., California Institute, '32; M.S., '34.
SIDNEY SCHAFER
VERNER FREDERICK HENRY SCHOMAKER Chemistry B.S., University of Nebraska, '34; M.S., '35.
JOHN RUSSELL SCHULTZ
JACK WILLIAM SCHWARTZ Civil Engineering B.S., California Institute, '35.
Allan Romic Scoville Electrical Engineering B.S., California Institute, '35.
WILLIAM REES SEARS Aeronautics B.Aero.E., University of Minnesota, '34.
HOWARD STANLEY SEIFERT ⁵
STUART LEWIS SEYMOUR Physical Education B.S., California Institute, '26.
THOMAS REEDER SHUGART
FOLKE KARL SKOOG Biology B.S., California Institute, '32.
ROBERT ELLIS SMITH
WILLIAM EDWARDS STEPHENS ²
FRED BEALS STITT
² High Potential Radiation Research Fund.

-

⁵Norman Bridge Fellow.

STAFF OF INSTRUCTION AND RESEARCH

ANGUS ELLIS TAYLOR ³
DONALD STINSON TAYLOR
ANGUS CAMPBELL TREGIDGA ³ Physics B.A., University of British Columbia, '32; B.App.Sc., '33; M.A., '35.
LEONARD FREDERICK UHRIG
ERLING SANBORN WALSETH Engineering Drawing B.S.C.E., South Dakota State College, '35.
JOHN ERWIN WALSTROM Physics B.S., New Hampshire State University, '32; M.A., Wesleyan Univer- sity, '34.
RALPH MAYHEW WATSON Mechanical Engineering B.S., California Institute, '27; M.S., '28.
DONALD LOOMIS WEBB
Moses B. WIDESS Electrical Engineering B.S., California Institute, '33; M.S., '34.
HAROLD FORBES WILEY
ROBERT WARREN WILSON
SAUL WINSTEIN
CARLOS CLAUDE WOOD
LOUVAN ELBERT WOOD Meteorology B.S., Alma College, '29; M.S., California Institute, '35.
DEAN EVERETT WOOLDRIDGE ³
BRADLEY HOBART YOUNG Aeronautics B.S., California Institute, '35.
³ Caroline W. Dobbins Fellow.

Visiting Professors, 1935-1936

DWIGHT C. CARPENTER, Ph.D., Professor of Chemistry and Chief in Research, Cornell University.

258 South Hudson Avenue

- BORIS EPHRUSSI, D.Sc., Associate Chief, Laboratory of Experimental Cytology, Institut de Biologie, Physico-Chemique, Paris.
- DONALD FORSHA JONES, Sc.D., Geneticist, Connecticut Agricultural Experiment Station.

675 South El Molino Avenue

Ju-Chi Li, Professor of Biology, Yenching University. 344 South Catalina Avenue

ROBERT S. MULLIKEN, Professor of Physics, University of Chicago.

HOWARD PERCY ROBERTSON, Ph.D., Assistant Professor of Mathematical Physics, Princeton University.

Athenæum

JERRY EDWARD WODSEDALEK, Ph.D., Professor of Zoology, University of Minnesota.

250-A South Catalina Avenue

Staff of Instruction and Research Summary

DIVISION OF PHYSICS, MATHEMATICS AND ELECTRICAL ENGINEERING

ROBERT A. MILLIKAN, Chairman

PROFESSORS

HAERY BATEMAN, Mathematics, Theoretical Physics, Aeronautics ERIC T. BELL, Mathematics IRA S. BOWEN, Physics PAUL S. EPSTEIN, Theoretical Physics WILLIAM V. HOUSTON, Physics CHARLES C. LAURITSEN, Physics ROBERT A. MILLIKAN, Physics SEELEY G. MUDD, X-Ray Therapy ROYAL W. SORENSEN, Electrical Engineering RICHARD C. TOLMAN, Physical Chemistry, Mathematical Physics HARRY C. VAN BUSKIEK, Mathematics EARNEST C. WATSON, Physics

VISITING PROFESSORS

ROBERT S. MULLIKEN, Physics HOWARD P. ROBERTSON, Mathematical Physics

RESEARCH ASSOCIATES

DINSMORE ALTER, Statistics

SAMUEL J. BARNETT, Physics

JESSE W. M. DUMOND, Physics

ASSOCIATE PROFESSORS ALEXANDER GOETZ, Physics S. STUART MACKEOWN, Electrical Engineering ARISTOTLE D. MICHAL, Mathematics J. ROBERT OFFENHEIMER, Theoretical Physics GENNADY W. POTAPENKO, Physics WILLIAM R. SMYTHE, Physics MORGAN WARD, Mathematics LUTHER E. WEAR, Mathematics FEITZ ZWICKY, Theoretical Physics

ASSISTANT PROFESSORS

CARL D. ANDERSON, Physics WILLIAM N. BIRCHBY, Mathematics CLYDE K. EMERY, X-Ray Therapy FREDERICK C. LINDVALL, Electrical Engineering FRANCIS W. MAXSTADT, Electrical Engineering RICHARD STEWART-HARRISON, X-Ray Therapy

INSTRUCTOR H. VICTOR NEHER

FELLOW IN PHYSICS OF JOHN SIMON GUGGENHEIM MEMORIAL FOUNDATION RAMÓN ENRIQUE GAVIOLA

FELLOW IN PHYSICS OF THE ROCKEFELLER FOUNDATION CHAO-YING MENG

NATIONAL RESEARCH FELLOWS IN PHYSICS TOM WILKERSON BONNER GILBERT W. KING

RESEARCH FELLOWS

L. REED BRANTLEY FRANK G. DUNNINGTON DWIGHT D. TAYLOR, Physics

COMMONWEALTH FUND FELLOW IN ASTROPHYSICS Andrew D. Thackeray

STAFF OF INSTRUCTION AND RESEARCH

INTERNATIONAL EXCHANGE FELLOW HANNS H. VON STENGEL, Physics

RESEARCH ASSISTANTS

LEO LEVI, X-Ray Therapy

SETH H. NEDDEMEYER, Physics

TEACHING FELLOWS AND ASSISTANTS

CHARLES K. ALEXANDER¹ HUBERT A. ARNOLD ROBERT A BECKER DAVID F BENDER VERNON L. BOLLMAN⁵ RICHARD T. BRICE¹ T. EVERETT BROWNE, JR. WILSON M BRUBAKER² EUGENE M. BRUNNER¹ ROBERT A. CLARKE³ KENNETH C. CRUMBINE¹ LEWIS A. DELSASSO² VICTOR ELCONIN¹ PAUL C. FINE⁴ MARK G. FOSTER WILLIAM A. FOWLER² R. HOWARD GRIEST NEWMAN A. HALL³ PAUL F. HAWLEY SHERWOOD K. HAYNES ARTHUR HEMMENDINGER³ IVAR E. HIGHBERG³ OSCAR B. JACKSON Robert C. Kendall

WILLIAM B. MCLEAN³ JAMES W. MCRAE WILLIAM A. MERSMAN³ FRANK OPPENHEIMER SIMON PASTERNACK EDWIN W. PAXSON¹ WILLIAM H. PICKERING JOHN R. PIERCE LOUIS A. PIPES LOUIS T. RADER SIMON RAMO JOHN S. RINEHART ALLAN R. SCOVILLE HOWARD S. SEIFERT⁵ THOMAS R. SHUGART ROBERT E. SMITH WILLIAM E. STEPHENS² ANGUS E. TAYLOR³ ANGUS C. TREGIDGA³ JOIIN E. WALSTROM DONALD L. WEBB Moses B. Widess HAROLD F. WILEY DEAN E. WOOLDRIDGE³

¹Henry Laws Fellow. ²High Potential Radiation Research Fund. ³Caroline W. Dobbins Fellow. ⁴Charles A. Coffin Fellow. ⁵Norman Bridge Fellow.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING ARTHUR A. Noves, Chairman

PROFESSORS

STUART J. BATES, Physical Chemistry JAMES E. BELL, Chemistry WILLIAM N. LACEY, Chemical Engineering ARTHUR A. NOYES, Chemistry LINUS PAULING, Chemistry RICHARD C. TOLMAN, Physical Chemistry, Mathematical Physics

> VISITING PROFESSOR DWIGHT C. CARPENTER, Chemistry

ASSOCIATE PROFESSORS ROSCOE G. DICKINSON, Physical Chemistry HOWARD J. LUCAS, Organic Chemistry Don M. Yost, Inorganic Chemistry

RESEARCH ASSOCIATES

JOSEPH B. KOEPFLI, Organic Chemistry ALFRED E. MIRSKY, Organic Chemistry

ASSISTANT PROFESSORS

RICHARD M. BADGER, Chemistry Arnold O. BECKMAN, Chemistry ERNEST H. SWIFT, Analytical Chemistry

SENIOR FELLOWS IN RESEARCH

LAWRENCE O. BROCKWAY BRUCE H. SAGE JAMES H. STURDIVANT GEORGE W. WHELAND

NATIONAL RESEARCH FELLOWS

LUDO K. FREVEL

LINDSAY HELMHOLZ

GILBERT W. KING

COMMONWEALTH FUND FELLOW H. O. JENKINS

RESEARCH FELLOWS

CHARLES D. CORYELL JACK H. SHERMAN SIDNEY WEINBAUM CHESTER E. WILSON

RESEARCH ASSISTANTS

SIMON H. BAUER

JOHN E. SHERBORNE¹ Donald C. Webster¹

TEACHING FELLOWS AND ASSISTANTS

THOMAS F. ANDERSON EDWIN N. LASSETTRE JOHN Y. BEACH³ HABBY LOTZKAR THOMAS J. DEAHL³ DARRELL W. OSBORNE CLARENCE L. DUNN KENNETH J. PALMER VERNER F. H. SCHOMAKER EUGENE H. EYSTER² CLIFFORD S. GARNER FRED B. STITT EMERSON W. GREEN DONALD S. TAYLOR DAVID HARKER SAUL WINSTEIN E. RUSSELL KENNEDY

¹American Petroleum Institute. ²Henry Laws Fellow. ²Caroline W. Dobbins Fellow.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING FRANKLIN THOMAS, Chairman

PROFESSORS

HARRY BATEMAN, Mathematics, Theoretical Physics, Aeronautics W. HOWARD CLAPP, Mechanism and Machine Design ROBERT L. DAUGHERTY, Mechanical and Hydraulic Engineering FREDERIC W. HINRICHS, JR., Mechanics THEODOR VON KARMAN, Aeronautics R. R. MARTEL, Structural Engineering FRANKLIN THOMAS, Civil Engineering

VISITING PROFESSOR

Sverre Petterssen, Meteorology

ASSOCIATE CARL C. THOMAS, Engineering Research

ASSOCIATE PROFESSORS

ARTHUR L. KLEIN, Aeronautics WILLIAM W. MICHAEL, Civil Engineering CLARK B. MILLIKAN, Aeronautics

ASSISTANT PROFESSORS

FRED J. CONVERSE, Civil Engineering ROBERT T. KNAPP, Mechanical Engineering IRVING P. KRICK, Meteorology ARTHUR E. RAYMOND, Aeronautics

INSTRUCTORS

DONALD S. CLARK, Mechanical Engineering W. A. KLIKOFF, Aeronautics ERNEST E. SECHLER, Drawing HERMAN J. STOEVER, Mechanical Engineering NATHANIEL W. WILCOX, Drawing

RESEARCH FELLOWS

Gottfried Dätwyler, Aeronautics Vito A. Vanoni, Hydraulics* Frank L. Wattendorf, Aeronautics

*Soil Conservation Service, Department of Agriculture.

RESEARCH ASSISTANTS

WILLIAM H. BOWEN, Aeronautics N. Albert Christensen, Hydraulics* Frederick D. Knoblock, Aeronautics Laverne D. Leeper, Hydraulics* Robert M. Oaks, Hydraulics* George H. Otto, Hydraulics* Harold F. Richards, Hydraulics* Merit P. Whitte, Hydraulics* Nathan D. Whitman, Jr., Hydraulics*

TEACHING FELLOWS AND ASSISTANTS

RAYMOND C. BINDER EUGENE BOLLAY WILLIAM BOLLAY ROLAND A. BUDENHOLZER ALEXANDER C. CHARTERS, JR. MILFORD CHILDERS CLYDE C. CHIVENS FRANCES H. CLAUSER MILTON U. CLAUSER NORMAN B. DEWEES JAMES M. FOX BOBERT B. FREEMAN VERNON A. C. GEVECKER THOMAS W. GRIFFITHS WALTER L. HOWLAND ABTHUR T. IPPEN JAMES H. JENNISON

HARRY M. KOONS P. ERVIN KRAGHT HAROLD L. LEVINTON CHARLES MACKINTOSH FRANK J. MALINA VICTOR MARTIN GILBERT D. MCCANN EGOR P. POPOFF W. CURTIS ROCKEFELLER JACK W. SCHWARTZ WILLIAM R. SEARS ERLING S. WALSETH RALPH M. WATSON CARLOS C. WOOD LOUVAN E. WOOD BRADLEY H. YOUNG

*Soil Conservation Service, Department of Agriculture.

CALIFORNIA INSTITUTE OF TECHNOLOGY

DIVISION OF THE GEOLOGICAL SCIENCES J. P. BUWALDA, Chairman

PROFESSORS

J. P. BUWALDA, Geology BENO GUTENBERG, Geophysics CHESTER STOCK, Paleontology

RESEARCH ASSOCIATES

ROBERT T. MOORE, Vertebrate Zoology HARRY O. WOOD, Seismology

> ASSOCIATE PROFESSOR IAN CAMPBELL, Petrology

ASSISTANT PROFESSOR HORACE J. FRASER, Mineralogy and Mineragraphy

> INSTRUCTOR JOHN H. MAXSON, Geology

CUR ATORS.

GEORGE H. ANDERSON, Physical Geology FRANCIS D. BODE, Vertebrate Paleontology EUSTACE L. FURLONG, Vertebrate Paleontology WILLIS P. POPENOE, Invertebrate Paleontology

> SCIENTIFIC ILLUSTRATOR JOHN L. RIDGWAY

RESEARCH FELLOWS

MAURICE DONNELLY, Geology RAYMOND A. PETERSON, Geophysics JOSHUA L. SOSKE, Geophysics

HAMPTON SMITH, Geology

TEACHING FELLOWS AND ASSISTANTS

EDMUND BORYS ROBERT P. BRYSON WILLIAM M. COGEN CHARLES A. DAWSON, JR. RUDOLF VON HUENE VINCENT C. KELLEY* LUIS E. KEMNITZER

DONALD D. MACLELLAN ELBURT F. OSBORN* WILLARD D. PYE SIDNEY SCHAFER JOHN R. SCHULTZ LEONARD F. UHRIG ROBERT W. WILSON

*Blacker Fellow.

DIVISION OF BIOLOGY

THOMAS HUNT MORGAN, Chairman

PROFESSORS

HENRY BORSOOK, Biochemistry THOMAS HUNT MORGAN, Biology ALFRED H. STURTEVANT, Genetics FRITS W. WENT, Plant Physiology ALFRED H. STURTEVANT, Genetics

BORIS EPHRUSSI DONALD F. JONES VISITING PROFESSORS

JU-CHI LI JERRY EDWARD WODSEDALEK

ASSOCIATE PROFESSOR ERNEST G. ANDERSON, Genetics

ASSISTANT PROFESSORS

THEODOSIUS DOBZHANSKY. Genetics ROBERT EMERSON, Biophysics STERLING H. EMERSON, Genetics HUGH M. HUFFMAN, Biochemistry GEORGE E. MACGINITIE, Biology CORNELIS A. G. WIERSMA, Physiology

INSTRUCTORS

GEORGE W. BEADLE, Biology ANTHONIE VAN HARREVELD, Physiology KENNETH V. THIMANN, Bacteriology ALBERT TYLER, Embryology

INTERNATIONAL RESEARCH FELLOW OF THE ROCKEFEILER FOUNDATION HANS G. E. BAUER

RESEARCH ASSISTANTS

WILLIAM R. BERGREN JAMES F. BONNER SIDNEY W. FOX LOWELL GREEN

CECIL E. P. JEFFREYS GEORGE H. MARMONT MARSTON C. SARGENT CHARLES L. SCHNEIDER JOHANNES VAN OVERBEEK

KELLOGG (UNIVERSITY) RESEARCH FELLOW PHILIP TRUMAN IVES

TEACHING FELLOWS AND ASSISTANTS

ROBERT DEV. BOCHE CLARENCE W. CLANCY WILLIAM G. CLARK

H. DAVID MICHENER DONALD F. POULSON FOLKE K. SKOOG

55

DIVISION OF ASTROPHYSICS

OBSERVATORY COUNCIL

GEORGE E. HALE, Chairman WALTER S. ADAMS

an Robert A. Millikan Arthub A. Noyes Henry M. Robinson

JOHN A. ANDERSON, Executive Officer Edward C. BARRETT, Secretary

ADVISORY COMMITTEE

WALTER S. ADAMS, Chairman CHARLES G. ABBOT IRA S. BOWEN JOHN P. BUWALDA W. HOWARD CLAPP PAUL S. EPSTEIN EDWIN HUBBLE THEODORE VON KARMAN R. R. MARTEL HENRY N. RUSSELL FREDERICK H. SEARES ROYAL W. SORENSEN

RICHARD C. TOLMAN

RESEARCH ASSOCIATE JOHN A. ANDERSON

SUPERVISING ENGINEER FOR THE 200-INCH TELESCOPE CAPTAIN C. S. MCDOWELL, U.S.N.

ASSOCIATES IN OPTICS AND INSTRUMENT DESIGN FRANCIS G. PEASE RUSSELL W. PORTER

SENIOR FELLOWS IN RESEARCH

RUDOLPH M. LANGER

JOHN D. STRONG

RESEARCH FELLOW JOSEF J. JOHNSON

STAFF OF INSTRUCTION AND RESEARCH

DIVISION OF THE HUMANITIES

CLINTON K. JUDY, Chairman

PROFESSORS

CLINTON K. JUDY, English Language and Literature GRAHAM A. LAING, Economics and Business Administration JOHN R. MACARTHUR, Languages WILLIAM B. MUNRO, History and Government THEODORE G. SOARES, Ethics

ASSOCIATES

HARDIN CRAIG, Literature	GODFREY DAVIES, History
MERLE E. CURTI, History	FREDERICK M. PADELFORD, Literature
Louis B.	WRIGHT, Literature

ASSOCIATE PROFESSORS

HORACE N. GILBERT, Business Economics GEORGE R. MACMINN, English Language and Literature

ASSISTANT PROFESSORS

HARVEY EAGLESON, English Language and Literature PHILIP S. FOGG, Business Economics WILLIAM HUSE, English Language and Literature ROGER STANTON, English Language and Literature RAY E. UNTEREINER, Economics and History

INSTRUCTOR

L. WINCHESTER JONES, English Language and Literature

GRADUATE ASSISTANTS

CARL F. J. OVERHAGE, Modern Languages WILLIAM H. PICKERING, History

CALIFORNIA INSTITUTE OF TECHNOLOGY

DIVISION OF PHYSICAL EDUCATION

R. W. Sorensen, Chairman

PHYSICAL DIRECTOR WILLIAM L. STANTON

ASSISTANT DIRECTOR HAROLD Z. MUSSELMAN

CONSULTING PHYSICIAN Edward D. Kremers

PHYSICAL TRAINER FLOYD L. HANES

ASSISTANTS

SIDNEY F. BAMBERGER Edgar H. Kienholz

WARREN T. POTTER, JR. STUART L. SEYMOUR

California Institute Associates

The California Institute Associates are a group of public-spirited citizens, interested in the advancement of learning, who have been incorporated as a non-profit organization for the purpose of promoting the interests of the California Institute of Technology.

OFFICERS

JAMES R. PAGE President ALBERT B. RUDDOCK 1st Vice-President JOHN HUDSON POOLE 2nd Vice-President MALCOLM MCNAGHTEN 3rd Vice-President

4th Vice-President PRESTON HOTCHKIS Secretary DONALD O'MELVENY Treasurer EDWARD C. BARRETT Asst. Sec'v. Asst. Treas.

DIRECTORS

John E. Barber I. C. Copley John S. Cravens George E. Farrand Thomas Fleming, Jr.

Stuart W. French S. M. Haskins Malcolm McNaghten R. H. Moulton E. J. Nolan Donald O'Melveny

James R. Page John Hudson Poole Albert B. Ruddock W. L. Valentine Archibald B. Young

MEMBERS

Fred S. Albertson George W. H. Allen William H. Allen, Jr. Mrs. Noel Arnold Mrs. James G. Bailey Allan C. Balch Mrs. Allan C. Balch Frenklin Baldwin Mrs. Russell H. Ballard Robert W. Campbell John E. Barber Harry J. Bauer Mrs. Albert C. Bilicke Mrs. Ellis Bishop Miss Eleanor M. Bissell Fred H. Bixby E. J. Blacker Mrs. R. R. Blacker Edward W. Bodman Mrs. Joseph Bond Franklin Booth Victor von Borosini J. G. Boswell

Mrs. Rebecca F. Boughton C. F. Braun Scott Brown Mrs. E. A. Bryant Mrs. Clara B. Burdette Carleton F. Burke R. R. Bush Frank R. Capra Frederick J. Carr Harry Chandler Norman W. Church Mrs. E. P. Clark Arthur M. Clifford George I. Cochran Thomas F. Cole I. C. Copley Hamilton H. Cotton S. Houghton Cox Shannon Crandall John S. Cravens

E. W. Crellin William C. Crowell Mrs. James A. Culbertson Mrs. Joseph B. Dabney Addison B. Day Thomas R. Dempsey Mrs. Donald R. Dickey Mrs. Edward L. Doheny E. E. Duque John H. Eagle Harry B. Earhart Mrs. Meyer Elsasser Melville G. Eshman Mrs. H. A. Everett George E. Farrand John H. Fisher Arnold K. Fitger Herbert Fleishhacker Arthur H. Fleming Thomas Fleming, Jr. Mrs. Frank P. Flint F. W. Flint, Jr.

Freeman A. Ford Stuart W. French Robert N. Frick Mrs. Robert N. Frick John Gaffey Mrs. Charles W. Gates Robert C. Gillis E. S. Gosney Mrs. Herbert J. Goudge Mrs. James G. Claude M. Griffeth George E. Hale Mrs. Girard van B. Hale Miss Evelyn Hamburger Mrs. F. A. Hardy Mrs. E. C. Harwood Arnold D. Haskell S. M. Haskins William C. Hay Mrs. Arthur Hill Mrs. Frank P. Hixon Joseph M. Hixon Collis H. Holladay W. I. Hollingsworth Webster B. Holmes William L. Honnold Mrs. William L. Honnold W. W. Mines W. S. Hook, Jr. Louis J. Hopkins Preston Hotchkis Mrs. William F. Howard Rupert Hughes Myron Hunt Willis G. Hunt Willard C. Jackson John E. Jardine Mrs. W. P. Jeffries Mrs. S. Herbert Jenks S. Fosdick Jones F. W. Kellogg A. N. Kemp H. H. Kerckhoff Mrs. William G. Kerckhoff Henry W. O'Melveny J. O. Koepfli R. H. Lacy

Mrs. William Lacy Oscar Lawler Fred B. Lewis Ralph B. Lloyd Edward D. Lyman Leonard S. Lyon Alexander Macbeth James E. MacMurrav Macpherson Fred S. Markham Alonzo C. Mather Mrs. George H. Maxwell Tom May Mrs. Anna Bissell McCay William C. McDuffie J. Wallace McKenzie Malcolm McNaghten Mrs. E. A. Merrill Edwin A. Meserve Ben R. Mever Mrs. Ben R. Meyer Mrs. John B. Miller Robert A. Millikan Ernest E. Millikin Robert T. Moore Alan E. Morphy Lindley C. Morton R. H. Moulton Harvey S. Mudd Seeley G. Mudd Mrs. Seeley W. Mudd W. C. Mullendore William B. Munro Daniel Murphy Walter M. Murphy Arthur Noble E. J. Nolan Arthur A. Noyes Donald O'Melveny John O'Melveny Stuart O'Melveny

Patrick H. O'Neil Mrs. Benjamin E. Page James R. Page Mrs. James R. Page Mrs. June Braun Pike Clarence B. Piper J. Hudson Poole Mrs. J. Hudson Poole Francis F. Prentiss Mrs. Francis F. Prentiss William M. Prindle Charles H. Prisk Charles McCormick Reeve Louis D. Ricketts Mrs. Louis D. Ricketts Henry M. Robinson R. I. Rogers Albert B. Ruddock Mrs. Albert B. Ruddock Howard J. Schoder Silsby M. Spalding Charles F. Stern Mrs. Frederick H. Stevens Mrs. Charles Stinchfield Reese H. Tavlor Charles H. Thorne Mrs. Joseph E. Tilt Mrs. John Treanor Mrs. John K. Urmston Edward R. Valentine W. L. Valentine Mrs. W. L. Valentine William W. Valentine J. Benton Van Nuys Charles B. Voorhis Mrs. Paul M. Warburg Thomas W. Warner Mrs. Gurdon W. Wattles Philip Wiseman Casey A. Wood Archibald B. Young Gerald C. Young

Educational Policies

In pursuance of the plan of developing an institute of science and technology of the highest grade, the Trustees have adopted the following statement of policies:

(1) The Institute shall offer two four-year Undergraduate Courses, one in Engineering and one in Science. Both of these Courses shall lead to the degree of Bachelor of Science and they shall also possess sufficient similarity to make interchange between them not unduly difficult.

The four-year Undergraduate Course in Engineering (2)shall be of a general, fundamental character, with a minimum of specialization in the separate branches of engineering. It shall include an unusually thorough training in the basic sciences of physics, chemistry, and mathematics, and a large proportion of cultural studies; the time for this being secured by eliminating some of the more specialized technical subjects commonly included in undergraduate engineering courses. It shall include, however, the professional subjects common to all branches of engineering. It is hoped in this way to provide a combination of a fundamental scientific training with a broad human outlook, which will afford students with engineering interests the type of collegiate education endorsed by leading engineers-one which avoids on the one hand the narrowness common among students in technical schools, and on the other the superficiality and the lack of purpose noticeable in many of those taking academic college courses.

(3) Fifth-year Courses leading to the degree of Master of Science shall be offered in the various branches of engineering for the present in civil, mechanical, electrical, aeronautical, and chemical engineering. In these Courses the instruction in basic engineering subjects shall be maintained at the highest efficiency so that the graduates from them may be prepared with especial thoroughness for positions as constructing, designing, operating, and managing engineers.

(4) The four-year Undergraduate Course in Science shall afford, even more fully than is possible in the Engineering Course, an intensive training in physics, chemistry, and mathematics. In its third and fourth years groups of optional studies shall be included which will permit either some measure of specialization in one of these basic sciences or in geology, paleontology, biology, astrophysics, or in the various branches of engineering. This Course shall include the same cultural studies as does the Engineering Course, and in addition, instruction in the German and French languages. Its purpose will be to provide a collegiate education which, when followed by one or more years of graduate study, will best train the creative type of scientist or engineer so urgently needed in our educational, governmental, and industrial development, and which will most effectively fit able students for positions in the research and development departments of manufacturing and transportation enterprises.

(5) Fifth-year Courses leading to the degree of Master of Science shall be offered in the sciences of physics, astrophysics, mathematics, chemistry, geology, geophysics, paleontology, and biology. A considerable proportion of the time of these Courses shall be devoted to research. These will continue the training for the types of professional positions above referred to.

(6) Throughout the period of undergraduate study every effort shall be made to develop the character, ideals, breadth of view, general culture, and physical well-being of the students of the Institute. To this end the literary, historical, economic, and general scientific subjects shall continue to be taught by a permanent staff of men of mature judgment and broad experience; the regular work in these subjects shall be supplemented by courses of lectures given each year by men of distinction from other institutions; and the weekly assemblies, addressed by leading men in the fields of education, literature, art, science, engineering, public service, commerce, and industry, shall be maintained as effectively as possible. Moderate participation of all students in student activities of a social, literary, or artistic character, such as student publications, debating and dramatic clubs, and musical clubs, shall be encouraged; and students shall be required to take regular exercise, preferably in the form of intramural games or contests affording recreation.

(7) In all the scientific and engineering departments of the Institute research shall be strongly emphasized, not only because of the importance of contributing to the advancement of science and thus to the intellectual and material welfare of mankind, but also because research work adds vitality to the educational work of the Institute and develops originality and creativeness in its students.

(8) In order that the policies already stated may be made fully effective as quickly as possible, and in order that the available funds may not be consumed merely by increase in the student body, the registration of students at any period shall be strictly limited to that number which can be satisfactorily provided for with the facilities and funds available. And students shall be admitted, not on the basis of priority of application, but on that of a careful study of the merits of individual applicants, so that the limitation may have the highly important result of giving a select body of students of more than ordinary ability. A standard of scholarship shall also be maintained which rapidly eliminates from the Institute those who, from lack of ability or industry, are not fitted to pursue its work to the best advantage.

Educational Buildings and Facilities

THROOP HALL

Throop Hall, named for Amos G. Throop, founder of Throop Polytechnic Institute, out of which the California Institute developed, is the central building on the campus. It was erected in 1910, with funds supplied by a large number of donors. It now contains the offices of administration, the class rooms and drafting rooms of the engineering departments, and some of the engineering laboratories.

NORMAN BRIDGE LABORATORY OF PHYSICS

The Norman Bridge Laboratory of Physics, the gift of the late Dr. Norman Bridge of Chicago, consists of two units of five floors each, connected at the north by a third unit of two floors, so as to form three sides of a hollow square. One of these units has in addition a special photographic laboratory on a partial sixth floor, and each has on its large flat roof excellent facilities for outdoor experimentation. The building contains the Norman Bridge Library of Physics, to provide for which Dr. Bridge gave \$50,000.

The east unit contains a lecture room seating 260 persons, two large undergraduate laboratorics with adjoining dark rooms and apparatus rooms, three class rooms, three laboratories for advanced instruction, nine offices, a stock and chemical room, the graduate library of physics, and twelve research rooms, besides shops, machinery, switchboard, and storage battery rooms.

The west unit is used primarily for research. It contains forty-five research rooms as well as a seminar room, photographic dark rooms, a chemical room, fourteen offices, and switchboard, storage-battery, electric furnace and machinery rooms. On the second and third floors of this unit of the Norman Bridge Laboratory, is housed, temporarily, the Division of Geology and Paleontology. The central unit has in the basement eight more research rooms, thus bringing the number of rooms devoted exclusively to research up to sixty-five. On the first floor is the general library and the engineering library of the Institute.

THE HIGH-POTENTIAL RESEARCH LABORATORY

A high-potential laboratory, provided by the Southern California Edison Company, forms a companion building to the first unit of the Norman Bridge Laboratory, which it closely resembles in external design and dimensions. The equipment in this laboratory includes a million-volt transformer specially designed by R. W. Sorensen, which has a normal rating of 1,000 kilovolt amperes but is capable of supplying several times the rated load at the above potential, with one end of the winding grounded, and a 1,000 kilovolt surge generator supplemented by cathode-ray oscillographs and other apparatus used in the study of electric surges (artificial lightning) and its effect upon electrical machinery. This laboratory is used both for the pursuit of special scientific problems connected with the structure of matter and the nature of radiation, and for the conduct of the pressing engineering problems having to do with the improvement in the art of transmission at high potentials. It also provides opportunities for instruction in this field, such as are not at present easily obtainable by students of science and engineering.

GATES CHEMICAL LABORATORY

The first unit of the Gates Chemical Laboratory, the gift of the late C. W. Gates and P. G. Gates, includes laboratories used for undergraduate instruction in Inorganic Chemistry, Analytical Chemistry, Organic Chemistry, Physical Chemistry, and Instrumental Analysis.

The remainder of this unit is devoted to facilities for research work. There are ten unit laboratories for physico-chemical research; organic and biochemical research laboratories; and research laboratories of photochemistry and radiation chemistry. In separate rooms special research facilities are also provided, including a well-equipped instrument shop, a students' carpenter shop, a glass-blowing room, a storage battery room, and large photographic dark rooms.

The second unit of the laboratory adjoins the first unit on the west, and is two stories in height. It contains a lecture room, seating 150 and completely equipped for chemical demonstrations of all sorts; a seminar room, a chemistry library, a small lecture room seating about 30 persons, class rooms, four research laboratories, professors' studies, a storeroom for inflammable chemicals, and the usual machinery, switchboard, and service rooms.

RESEARCH LABORATORY OF APPLIED CHEMISTRY

With the Gates Chemical Laboratory is associated the Research Laboratory of Applied Chemistry, which is located in the Engineering Research Building. This research laboratory is equipped for carrying on chemical reactions on a fifty or a hundred pound scale. The machinery is as nearly like commercial plant equipment as is consistent with its size. It includes apparatus for grinding and pulverizing, melting, mixing, dissolving, extracting, pumping, decanting, centrifuging, filtering (by gravity, pressure, suction, plate and frame, and leaf filters), evaporating under pressure or vacuum, fractionating, condensing, crystallizing, drying under pressure or vacuum, and absorbing gases and vapors.

ENGINEERING RESEARCH LABORATORY AND HEATING PLANT

Through funds provided in part by the late Dr. Norman Bridge, and in part from other sources, the Institute has erected an engineering building 50 by 140 feet in size. One section of this is occupied by the boiler plant which supplies all the steam for both heating and laboratory purposes. The equipment consists of two Babcock and Wilcox Sterling boilers, each of 300 boiler horse-power capacity and capable of operation at 200 per cent of rating and with a steam pressure of 250 pounds per square inch. The plant is also fully equipped with all the auxiliary equipment necessary for comprehensive tests of all portions of the installation. There are also heat exchangers in which water is heated by steam, and centrifugal pumps driven by steam turbines to circulate the hot water for heating some of the buildings on the campus.

The other section of the building is supplied with water, gas, direct and alternating current, compressed air, and steam. It provides space for chemical engineering research including petroleum investigation sponsored by the American Petroleum Institute. There is also a dynamometer room containing a 150 h.p. electric dynamometer which may be operated either as a generator or a motor, thus making possible tests of automobile engines, centrifugal pumps, and similar equipment.

STEAM, GAS ENGINE, AND HYDRAULIC LABORATORIES

The undergraduate laboratory work in the fields of thermodynamics and hydraulics is provided for in a building of temporary construction. Facilities are there available for the customary tests of steam engines, turbines, gas and oil engines, air compressors, blowers, centrifugal and other pumps, hydraulic turbines, and for various experiments on the flow of fluids.

HYDRAULIC STRUCTURES LABORATORY

The hydraulic structures laboratory is located out of doors adjoining the undergraduate hydraulic laboratory. At present the equipment includes: (a) A model basin of about 2000 square feet in which river, harbor, and beach problems can be studied. In addition to metered water inlets and outlets at three points, it is provided with a wave machine the full width of the basin and an automatic tide machine which together make it possible to superimpose waves of various magnitudes, frequencies, and directions

upon any desired tide cycle. This was first constructed in cooperation with the Los Angeles Gas and Electric Corporation and the Los Angeles County Flood Control District for use in a study of the effect of proposed changes in the outlet of the San Gabriel River at Alamitos Bay. Since the completion of that work it has been in use on other cooperative river and harbor studies. (b) A channel platform 10 feet wide and 100 feet long for studying high velocity flow. This platform can be adjusted to any gradient up to 12 per cent and is provided with a metered water supply of 5 cubic feet per second. It has been installed in cooperation with the Los Angeles County Flood Control District to study the phenomena encountered in flood control channels in foothill regions where the flow velocity is above the critical. (c) A concrete flume 5 feet wide, 5 feet deep, and 35 feet long for use in weir, spillway, and allied problems requiring a deep basin. This flume is provided with a metered water supply at two points. It has been constructed in cooperation with the California Forest Experiment Station of the U.S. Forest Service for the study of some of the problems arising at the San Dimas Experimental Forest installation

HYDRAULIC MACHINERY RESEARCH LABORATORY

The hydraulic machinery laboratory of the Metropolitan Water District of Southern California, installed at the Institute, offers unique opportunities for research on centrifugal pumps and hydraulic turbines and for various other investigations in hydrodynamics. Included in the facilities are an electric dynamometer of special design capable of absorbing or delivering 500 h.p. and operating at speeds up to 5,500 r.p.m.; main service pumps capable of delivering 16 cu. ft. of water per sec. and developing heads up to 750 ft. of water; two pressure tanks of 1,000 cu. ft. capacity each and designed for a working pressure of 300 lbs. per sq. in.; two accurately calibrated volumetric measuring tanks of 300 and 1,000 cu. ft. capacity; and other smaller pumps and miscellaneous apparatus. Instrumental equipment designed by the Institute staff provides means for measuring pressures, rates of flow, torques, and speeds with a precision of approximately 0.1 per cent. Included in this is a system of speed regulation for the dynamometer which insures constant speed independent of the load in steps of $\frac{1}{2}$ revolution per minute from 500 r.p.m. to 5,500 r.p.m. To insure precision of measurements an independent time standard of the quartz crystal type has been installed. This laboratory is available for the use of the staff and qualified students at all times when it is not being used for the purposes of the Metropolitan Water District.

SOIL CONSERVATION LABORATORY

During the early part of 1935 an agreement was reached between the Soil Conservation Service of the U.S. Department of Agriculture and the California Institute of Technology which resulted in the establishment of a cooperative laboratory for the purpose of studying the hydraulic aspects of soil erosion and the flow characteristics of streams carrying suspended and bed loads. To house that part of the work to be carried out on the campus a one story building is in the process of erection. It will have a floor space of about 4500 square feet and will contain the equipment used in the study of the more fundamental aspects of the problem. This equipment will include: (a) A transportation flume designed to study primarily the flow of a fluid carrying a suspended load. It will be of the closed circuit type and will circulate both the water and the solids in suspension. It will be about 70 feet long and will have an adjustable gradient. The maximum rate of flow will be 5 cubic feet per second. (b) A flume for the study of rate of reduction of bed load. This will be also of the circulating type with a mechanical elevator for the larger particles of the bed material. (c) A glass-walled flume for special studies. In addition to this apparatus, the building will provide space for a fineness laboratory and shop space for the construction of models and instruments for use in the investigations.

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY

Funds for the construction of the Daniel Guggenheim Aeronautical Laboratory and to aid in its operation for a period of ten years were provided through a gift of \$350,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics. The building is 160 feet long by about 55 feet wide, and has five floors. The largest item of equipment is a wind tunnel of the Göttingen closed circuit type with a working section 10 feet in diameter. Provision is made for using the working section either as an open or closed type. A 750 horse-power, direct-current motor drives a 15-foot propeller, and a wind velocity of considerably more than 200 miles per hour has been produced. A complete set of aerodynamical balances permit testing and research work of all kinds to be performed in the wind tunnel. An aerodynamics laboratory contains several small wind tunnels and a considerable amount of auxiliary apparatus for the study of the basic problems connected with turbulent flows. A large structures laboratory has been equipped with specially designed testing machines with which a series of researches is now in progress, dealing chiefly with the problems connected with the modern use of stressed skin or monocoque structures. A completely equipped photoelasticity laboratory in the basement is being used for researches on the distribution of stresses in various complicated types of structure. On the first floor are the observation room and model assembly room for the wind tunnel, a wood shop large enough for the building of complete airplanes, and the structures laboratory. On the second floor are offices, a group of six small laboratories for research, and a large meteorological classroom and laboratory. The third floor contains the balance room in which the wind tunnel measurements are made, a seminar room, library, drafting rooms, aerodynamics laboratory, and five offices.

DABNEY HALL OF THE HUMANITIES

Through the generous gift of Mr. and Mrs. Joseph B. Dabney, a Hall of the Humanities was completed in September, 1928. It is a three-story building, located to the east of the Gates Chemical Laboratory, with its main entrance facing the plaza. The building contains provision for various undergraduate activities, lecture rooms, a treasure room for the exhibition of pictures and other works of art, a library-reading room, conference rooms and studies, and in the east wing a very attractive lounge, on the north side of which a series of windows open out upon a tiled patio and an ornamental garden.

CULBERTSON HALL

Culbertson Hall, an auditorium seating 500 persons, erected in 1922, provides facilities for the Institute assemblies, lectures, and concerts, as well as for various social functions both of students and faculty. It was named in honor of the late Mr. James A. Culbertson, who was a trustee of the Institute and Vice-President of the Board during the years 1908 to 1915.

SEISMOLOGICAL RESEARCH LABORATORY

The Seismological Research Laboratory is located about four miles west of the Institute on a granite ridge affording firm bedrock foundation for the instrument piers. The investigations at the laboratory relate mainly to earth movements originating within a radius of about two hundred miles. The seismograms from six branch stations, built and maintained with the aid of cooperating agencies in Southern California, contribute greatly to these studies.

While devoted mainly to research, the laboratory is open to qualified students registered at the California Institute who desire advanced training in Seismology.

The laboratory is operated jointly by the California Institute and the Carnegie Institution of Washington. The general program of research is outlined by a committee of which Dr. Arthur L. Day is chairman and consisting of Messrs. J. A. Anderson, H. O. Wood, Beno Gutenberg, and J. P. Buwalda.

THE WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES

The first unit of the William G. Kerckhoff Laboratories of the Biological Sciences, the present quarters of the department, contains over 60 rooms, including lecture rooms, seminar rooms, undergraduate laboratories, private research rooms, and four constant temperature rooms. For work in plant genetics there is a ten-acre farm with greenhouses located at Arcadia, about five miles from the Institute.

A marine station has also been established at Corona del Mar. The building contains four large rooms and several smaller ones which give ample opportunity for research work in experimental biology in general. The proximity of the marine station to Pasadena (about 50 miles) makes it possible to supply the biological laboratories with living materials for research and teaching. The fauna at Corona del Mar and at Laguna Beach, which is near-by, is exceptionally rich and varied, and is easily accessible.

W. K. KELLOGG LABORATORY OF RADIATION

The facilities for research in the field of radiation were greatly increased by the erection of a building designed and equipped especially for high potential X-ray work. The building and its special equipment are the gift of Mr. W. K. Kellogg of Battle Creek, Michigan. It is located south of Throop Hall and adjacent to the High Potential Laboratory, which it resembles closely in architecture. The principal feature of the new building is the large equipment room, 60 feet long, 30 feet wide, and 68 feet from floor to ceiling. In this room the high potential X-ray tube, designed by Dr. C. C. Lauritsen, is located, together with the transformers and other high potential accessories. The room is sur-
rounded by heavy concrete walls and all operation and observation is carried out in adjoining rooms thoroughly protected from the radiation. In addition there are twenty-five rooms located on five floors, used as research rooms and offices for the staff and graduate students.

The work in this laboratory has been mainly therapeutic research work under the direction of Professor Seeley G. Mudd, and research in nuclear physics under the general direction of Professor C. C. Lauritsen. In the therapeutic work irradiation is used in the treatment of selected cases of inoperable cancer. The potential first used in this treatment was 550,000 volts, but since June, 1933, this has been increased to 850,000 volts.

The research on the purely physical phases of high-voltage X-Rays is conducted under the direction of Dr. C. C. Lauritsen.

LIBRARIES

The library of the Institute comprises the General Library and six departmental libraries: for Physics, Chemistry, Geology, Biology, Aeronautics, and the Humanities.

ASTROPHYSICS LABORATORY AND SHOPS

Statements concerning these buildings will be found on pages 111 to 114.

Athenaeum

The Athenæum, a handsome structure in the Mediterranean style of architecture, fittingly furnished and equipped, with grounds attractively landscaped and planted, is the gift of Mr. and Mrs. Allan C. Balch.

The purpose of the Athenæum is to provide a place and opportunity for contact between the distinguished foreign scientists and men of letters temporarily in residence from time to time at the California Institute, the Mount Wilson Observatory and the Henry E. Huntington Library and Art Gallery, the staffs and graduate students of those institutions, and the patrons and friends of science and education in Southern California making up the California Institute Associates.

The Athenæum contains on the first floor a large and beautiful lounge, a library, a main dining-room, three small dining-rooms, and, adjoining the main dining-room—and planned so that the two rooms can be thrown together for large banquets—a room for scientific and other lectures, known as the "Hall of the Associates," in addition to a completely-equipped kitchen and the necessary service rooms. On the upper floors are very attractively furnished rooms and suites, each with private bath, for visiting professors, members of the staffs and graduate students of the three institutions named, and other members of the Athenæum. An attractive writing room and lounge are provided on a mezzanine floor for the exclusive use of women.

Student Houses

On the California Street side of the Institute campus, four student houses have been erected and are known as Dabney House, Ricketts House, Blacker House, and Fleming House. The first three are the gifts of the late Mr. Joseph B. Dabney and Mrs. Dabney, Dr. and Mrs. L. D. Ricketts, and the late Mr. R. R. Blacker and Mrs. Blacker, respectively. The last is the gift of some twenty donors and is named Fleming House, in recognition of Mr. Fleming's great part in the development of the California Institute.

These four houses in Mediterranean style harmonizing with the Athenæum, were, like the latter building, designed by Gordon B. Kaufmann. While built in a unified group, each house is a separate unit providing accommodations for about seventy-five students; each has its own dining-room, reading room, and lounge, but all are served from a common kitchen.

All four houses have attractive inner courts surrounded by portales. Most of the rooms are single rooms, but there are a limited number of rooms for two. All the rooms are plainly but adequately and attractively furnished. The plans of the buildings are such that within each of the four houses there are groupings of rooms for from twelve to twenty students, with separate entries for each group.

The completion of this first group of residence halls marks the first step in a plan to meet the housing and living problems of the students in such a way as to develop a series of eight residence halls, "each to have its own distinctive atmosphere, each to be the center about which the loyalties developed in student days and the memories of student life shall cluster."

By action of the Board of Trustees, all undergraduate students are expected to live in the Student Houses unless permission is given by one of the Deans to live elsewhere. This provision normally will not be given except for reasons of emergency.

Extra-Curricular Opportunities

LECTURE AND CONCERT COURSES

Through a cooperative arrangement with the Pasadena Lecture Course Committee there are given at the Institute assemblies a number of lectures on science, literature, current events, and other subjects of general interest, by speakers of national and international note brought to Pasadena by the Committee. Weekly public lectures in science, illustrated by experiments, are given by the members of the Institute faculty in the lecture rooms of the Norman Bridge Laboratory of Physics and the Gates Chemical Laboratory. Lectures given from time to time at the Institute under the auspices of Sigma Xi and of the Astronomical Society of the Pacific are open to the students. They may also arrange to visit the Huntington Library and Art Gallery, and members of the Institute staff give talks to small groups of students preceding the visits to the art gallery on the pictures there exhibited.

STUDENT ORGANIZATIONS AND ACTIVITIES

The students are organized into an association known as the Associated Student Body, of which all are members, to deal with affairs of general concern to the students, and with such matters as may be delegated to them by the faculty. The Student Body elects its officers and a board of control, which investigates breaches of the honor system, or cases of misconduct, and recommends disciplinary penalties to the faculty.

Coordination in regard to campus affairs between faculty and students is obtained through periodic conferences of the Faculty Committee on Student Relations, the Board of Directors of the Student Body, and the Board of Control.

The Faculty Committee on Student Relations, in conjunction with the Board of Directors of the Student Body, arrange each year a series of lectures for the freshmen emphasizing (a) social usage and Institute traditions; (b) the value of undergraduate activities and the recognition by the business world of the character and qualities developed through participation in those activities; (c) the fact that studies need not keep students from a reasonable participation in extra-curricular interests; and (d) the fact that every student can find at the Institute a wide range of activities from which to choose.

The Associated Students exercise general direction of matters of undergraduate concern in cooperation with the faculty. Athletic contests are managed by the Athletic Council, composed of faculty and student representatives. The student body, through its elected representatives, manages THE CALIFORNIA TECH. a weekly paper, and the BIG T, the annual. A glee club, an orchestra, and a band are maintained, with assistance from the Institute. There are at the Institute student branches of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Society of Civil Engineers. A Chemists' Club and a Geology-Paleontology Club include men interested in these particular fields. Other organizations are the Dramatic Club, the Press, the Throop, the Varsity, the Walrus, the Cosmopolitan, the Photo, the Radio, the Aero and the Newman Clubs.

The Astronomy and Physics Club, while composed of members of the faculty, graduate students of the Institute, and members of the staffs of neighboring scientific institutions, admits to its meetings undergraduate students who may be interested in its discussions.

Sigma Xi is represented at the Institute by an active chapter. Graduate students who have demonstrated their ability to prosecute research are eligible for membership. Undergraduate students who have shown particular interest and aptitude in research are elected to associate membership.

A chapter of Tau Beta Pi, the national scholarship honor society of engineering colleges, is maintained at the Institute. Elections are made each year from the highest eighth of the junior class, and from the highest quarter of the senior class.

A chapter of Pi Kappa Delta, national forensic honor society, elects to membership students who have represented the Institute

in intercollegiate debate, oratorical or extempore speaking contests. The forensic interests of the Institute include also membership in the Southern California Public Speaking Association. Under the auspices of this association the Institute debaters engage in an annual schedule of six debates with other Southern California colleges, and in annual oratorical and extempore contests. Debates are also scheduled with near-by colleges, and frequently with eastern teams traveling through California. On the Pi Kappa Delta trips to the National Conventions, debates are scheduled with the best of the institutions that can be met en route.

To train the Institute speakers for these various intercollegiate contests, a debate course is offered by the English department, and much individual coaching is given the members of the teams. During the second and third terms a special class for freshmen gives the members of that class an opportunity to prepare for the freshman debates, in which the first-year men of six other colleges are met. A number of intramural practice debates, and the annual contest for the Conger Peace Prize, afford all men interested in public speaking an opportunity to develop their abilities.

Exceptional facilities in dramatic work are afforded the student. Each year a classical play, Greek or Roman, is presented under the auspices of Pi Kappa Delta, participation in it, however, being open to the whole student body. A modern play is given under the auspices of the English Department, open likewise to all students. Both of these plays are produced under the direction of Professors Eagleson and Stanton of the English department.

A Young Men's Christian Association has its office in Dabney Hall and performs many valuable services. Receptions for new students, hikes, bi-weekly luncheons, meetings, classes for the study of life and other problems are conducted by this organization. Its program and membership are open to all students at no expense.

Student Health and Physical Education

The Institute student health program consists of three principal features. The first is a thorough physical examination of all students entering the Institute by specialists on the staff of the Pasadena Hospital. The second feature of the program provides for a consulting physician, Dr. E. D. Kremers, who is in his office on the campus in the William G. Kerckhoff Laboratory of the Biological Sciences each day, and may be consulted by the students without charge. The third is the provision by the Institute of an insurance fund, through the payment of an annual fee of \$3 by every graduate and undergraduate student, to assist in the defraying of expenses in cases of emergency requiring hospitalization.

The program of physical education is designed to give physical development to all undergraduate students and to provide graduate students with opportunity for recreational exercise. The required work is divided into three parts: (1) corrective exercises for those physically deficient; (2) group games; (3) fundamentals of highly organized athletics. This work is modified by various activities designed to encourage voluntary recreational exercises, including intercollegiate and intramural games and sports.

Requirements for Admission to Undergraduate Standing

ADMISSION TO THE FRESHMAN CLASS

By action of the Trustees of the Institute the freshman class is limited to 160 students. These students are selected from the group of applicants on the basis of (a) high grades in certain required high school subjects and (b) satisfactory completion of entrance examinations in Mathematics, Physics, Chemistry, and English. The specific requirements in each of these groups are described below.

HIGH SCHOOL CREDITS

Each applicant must 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. Each applicant must offer all of the units in Group A and five units in Groups B and C. At least three of the latter must be in Group B.

(/ English	3 2
Group A:	Trigonometry	$1\frac{1}{2}$ $1\frac{1}{2}$ 1
	Chemistry United States History and Government	1 1
Group B:	Foreign Languages, Shop (up to 1 unit); additional Engli Mathematics, Laboratory Science, or History.	ish,

Group C: Drawing, Commercial subjects, additional Shop, etc.

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, if they are successful in passing the general entrance examinations; but no applicant will be admitted whose preparation does not include English 2 units, Algebra $1\frac{1}{2}$ units, Geometry 1 unit, Trigonometry $\frac{1}{2}$ unit, Physics 1 unit. All entrance deficiencies must be made up before registration for the second year.

Each applicant is expected to show that he has satisfactorily completed the above-stated required preparation, by presenting a complete scholastic record from an approved school.¹

ENTRANCE EXAMINATIONS

In addition to the above credentials, all applicants for admission to the freshman class are required to take entrance examinations. These examinations do not take the place of the highschool credentials, but serve to supplement them. The subjects covered are Chemistry, Physics, Mathematics, and English. The examinations are general in character; they are intended to show the applicant's ability to think and express himself clearly, and his fitness for scientific and engineering training, rather than to test memorized information. Specimens or samples of the examination questions for admission to the freshman class of the Institute are not available for distribution.

Prospective freshmen are expected to take the entrance examinations in Chemistry and English near the end of their junior year in high school, or one year prior to the date of expected admission to the Institute. The remaining examinations, in Mathematics and Physics, are ordinarily taken during April or May of the Spring prior to expected admission. Those students who have failed, for sufficient reason, to take the Chemistry and English examinations during the junior year may be permitted to take all four examinations during the Spring prior to admission.

Regular entrance examinations will be held at the Institute Saturday, April 25th, and Saturday, May 2nd, 1936. Applicants should report in the Lounge of Dabney Hall April 25th, at 8:30

81

⁴Incomplete scholastic records may be supplemented by examinations in particular subjects taken at the Institute. The scope of subject matter for these examinations is the same as that covered by standard high schools. Applicants taking examinations in United States History and Government must present their notebooks at the time of the examination. The schedule for 1936 is as follows: Tuesday, September 22, 9:00 A. M., Mathematics; 2:00 P. M., History and Foreign Languages.

A. M. The examinations on April 25th will be Chemistry and English and on May 2nd Mathematics and Physics. These examinations will be repeated September 11th and 12th if a sufficient number of duly qualified applicants is not selected from among those taking the Spring examinations. The examinations in Chemistry and English for high school juniors will be held in Dabney Hall on June 13th, 1936.

Students living at a distance from Pasadena may, upon request, be allowed to take the entrance examinations under the supervision of their local school authorities. Arrangements for examinations in absentia should include a letter to the Registrar from the individual directing the tests stating that the required supervision will be given.

PHYSICAL EXAMINATION

Each applicant must pass a physical examination prior to admission to the Institute. These examinations will be conducted for the Institute by the staff of the Pasadena Hospital. At the time of his registration each new student will be assigned an appointment for his examination. Registrations are tentative pending such reports, and are subject to cancellation if the reports are unsatisfactory. Students living at a distance are advised to consult their family physicians before coming to Pasadena in order to avoid unnecessary expense if physical defects exist which would prevent successful scholastic work. All students entering the Institute for the first time are required to be vaccinated or to submit satisfactory evidence of recent vaccination.

APPLICATION FOR ADMISSION

Application for admission to the Institute may be made at any time, but there is a distinct advantage in doing so by the first of April, or even earlier. This enables the Institute to make full use of all information available from high school sources. Applicants should submit their scholastic records before taking the entrance examinations. The scholarship records of students who have taken the examinations under the above arrangement should be forwarded to the Institute as soon as possible after the completion of the preparatory work.

Blanks for application for admission to the Institute will be provided upon request.

Applicants who comply with these conditions not later than June 22nd will be notified by the Registrar as to their acceptance on or about July 1.

Upon receipt of the registration fee of \$10.00 (which will be deducted from the first-term tuition), each accepted applicant will be sent a registration card which will entitle him to register, provided his physical examination is satisfactory. The registration card should be presented at the Dabney Hall Lounge September 23rd, 1936, at 8:30 A. M.

Checks or money order should be made payable to the California Institute of Technology.

ADMISSION TO UPPER CLASSES

For admission to the upper classes of the Institute applicants who have been students at other institutions of collegiate rank must present letters of honorable dismissal, together with statements showing in detail the character of their previous training, and the grades which have been received. It is advisable for students planning to transfer to send their credentials to the registrar at an early date. A personal interview is desirable; during the summer months it is well to arrange for this in advance. These students take examinations in Mathematics, Physics, and Chemistry; except that the examination in Chemistry is required only of those desiring to pursue the course in Science. Students must offer courses, both professional and general, substantially the same as those required in the various years at the Institute (see pages 141-154) or as soon as possible after admission make up their deficiencies. In case there is a question regarding either the quality or the extent of the previous work, examinations in the subjects concerned may be arranged.

The examinations in Mathematics, Physics and Chemistry taken by students planning to transfer to the third and fourthyear classes are the comprehensive review examinations required of all students of the Institute before they undertake the work of the third year, and are taken at the same time by students in the Institute and those desiring to transfer from other institutions. For men planning to enter the sophomore year similar review examinations covering the work of the freshman year are required. A representative set of previous examination papers will be sent to approved applicants upon request. From a study of these and of the content of the courses at the Institute, prospective students may judge for themselves which examinations they are prepared to take. Students are not required to take all of the examinations for admission to the classification of a given year as junior, sophomore, or freshman, but may take examinations in one or more subjects for admission to one class and in others for admission to the work of another class. Their ultimate classification will be determined by the committee on the basis of the results of all the examinations taken.

The examinations may be taken either in June or in September. The schedule for 1936 is as follows: Thursday, June 11, 9 A.M., Chemistry; Friday, June 12, 9 A.M., Mathematics; Saturday, June 13, 9 A.M., Physics; Friday, September 18, 9 A.M., Mathematics; Saturday, September 19, 9 A.M., Physics; 1:00 P.M., Chemistry.

Applicants are advised to take the examinations in June if possible. Those residing at a distance may take the June examinations under the supervision of their local college authorities, provided definite arrangements are made well in advance. Arrangements for examinations in absentia should include a letter to the registrar from the person directing the tests stating that the required supervision will be given.

Applicants for admission to the third and fourth years whose credentials have been approved may take advantage of the summer review courses in Mathematics and Physics to prepare for their examinations. These courses are offered during the three weeks preceding the opening of the fall term. The fee is \$20 for each course.

Applicants are advised to read the descriptions of the freshman and sophomore Physics, Mathematics, and Chemistry courses, and to note especially that the work in freshman Mathematics is chiefly calculus.

Because of the very thorough, intensive study of these subjects required in the first two years, students from other colleges, unless of ability above the average of Institute students, can not hope to transfer to the higher years of the Institute courses without incurring loss of time and difficulty in the pursuit of the more advanced subjects. Students intending to complete the Institute courses are therefore recommended, as far as possible, to take their freshman and sophomore work also at the Institute.

Physical examinations and vaccination are required as in the case of students entering the freshman class. If reports of these examinations are delayed until after registration it will be understood that registrations are tentative pending such reports and are subject to cancellation if the reports are unsatisfactory.

Expenses

TUITION

The tuition fee is three hundred dollars (\$300) a year, payable in three installments of \$100 each on registration day at the beginning of each term.

Students who attain honor standing at the end of their Freshman or Sophomore years are awarded prize scholarships carrying half tuition for the ensuing year, as described on page 97 of this Catalogue.

ASSOCIATED STUDENT BODY FEE

The Associated Student Body fee, payable by all undergraduate students, is \$13.45 a year, payable in three installments on registration day at the beginning of each term. This fee is used for the support of athletics and of other student activities. The subscription to the "California Tech" is 55 cents a year.

EMERGENCY HOSPITALIZATION FEE

There is an emergency hospitalization fee of \$3.00, payable by each student at the beginning of each year, to provide a certain amount of hospitalization, medical and surgical care, in accordance with regulations prescribed by the Board of Trustees and administered by the Institute Physician and the Faculty Committee on Student Health.

DEPOSITS AND LOCKER RENTAL

In the Division of Chemistry and Chemical Engineering an annual deposit of \$15.00 is required (payable on registration day at the beginning of the first term) to cover breakage and loss of laboratory materials. There is a 50c deposit for a locker key, and a \$2.00 deposit for a padlock issued in the drawing rooms. Deposits, in amounts specified by the departments concerned, are also required to cover the expenses of inspection trips

EXPENSES

taken by students in various courses. Lockers in Throop Hall may be rented by those who desire them at 50 cents a term.

BOOKS AND SUPPLIES

The cost of books and supplies for the first year is about \$65.00. In the upper classes the cost is generally less than this, but varies in different courses.

STUDENT HOUSES

Expenses in the Student Houses are as follows:

For room and 15 meals a week, beginning with breakfast Monday morning and ending with dinner Friday night, \$331.50 a year, payable in six installments during the academic year, as specified in the contract which is signed by each applicant for accommodations in the Houses. For room and 21 meals a week, \$391.00 a year, payable as in the case of the above specified rate.

Students in the Houses must supply their own blankets but bed linen and towels are furnished and laundered by the Institute.

There is also a charge of \$1.00 a term for telephone service; long distance toll charges being billed monthly.

House dues of \$2.00 a term are payable with other fees on registration day. These dues are collected by the Institute for the House organizations in the four Houses and are used by them to cover the expenses of their social and other House activities.

There is a deposit of \$10.00 payable by each student making reservation for accommodations in the Student Houses, this payment, upon occupancy of the room, constituting a deposit against breakage and loss. This deposit is not refunded if a student leaves the House during the year.

No rebate will be given for absence from room or table not

involving absence on legitimate Institute activity for two or more days or withdrawal from the Institute.

Application for rooms in the Student Houses may be made by addressing the Comptroller of the Institute.

LOAN FUNDS

The Cleveland Loan Fund was established by Miss Olive Cleveland for the purpose of aiding students to obtain an education. The income is lent without interest to worthy students who may need such assistance.

In 1923, Mr. Howard R. Hughes, of Galveston, Texas, gave \$5,000 to constitute an additional fund for loans to students. Mr. Raphael Herman, of Los Angeles, has provided a like sum to establish the Raphael Herman Loan Fund, which may be used for loans or for scholarships at the discretion of the Institute. A further gift of \$5,000 has been made by Mr. and Mrs. Arthur Noble of Pasadena to establish the Noble Loan and Scholarship Fund.

In 1932, Mr. and Mrs. Willard C. Jackson established at the Institute the Thomas Jackson Memorial Loan Fund in memory of their son, a member of the sophomore class of that year, who died during the fall term, at the beginning of a very promising career. The original gift for this fund was 10,000 and the donors have since added 10,000 to this amount. Loans from the fund are made to undergraduate or graduate students of superior ability who are in need of such assistance to meet the expenses of their education.

Applications for loans may be made to the Comptroller of the Institute.

STUDENT EMPLOYMENT

The Institute endeavors to be of assistance in aiding students to find suitable employment when it is necessary for them thus to supplement their incomes in order to continue their education.

EXPENSES

The requirements of the courses at the Institute are so exacting, however, that under ordinary circumstances students who are entirely or largely self-supporting should not expect to complete a regular course satisfactorily in the usual time. Students wishing employment are advised to write to the Secretary of the Institute Y. M. C. A. or the officer in charge of the National Youth Administration program conducted by the Institute in advance of their coming to the Institute.

The National Youth Administration program provides at the Institute during the year 1935-36 the sum of \$2200 per month, which may be earned by needy students assigned to socially desirable tasks, including research work carried on at the Institute. The amounts students may earn are: Undergraduates, average \$15, maximum \$25 per month. First year graduate students, average \$25, maximum \$30 per month. Advanced graduate students, average \$30, maximum \$40 per month.

Registration and General Regulations

Registration for the second term, 1935-1936, will take place January 2, 1936 (9 A.M. to 3 P.M.); for the third term, March 30, 1936 (9 A.M. to 3 P.M.). Registration for the first term, 1936-1937, will take place, for freshmen, September 23, 1936 (8:30 A.M.), for transfers from other colleges, September 24, 25, 1936 (9 A.M. to 3 P.M.), and for other students, September 25, 1936 (9 A.M. to 3 P.M.). A special fee of two dollars is charged for registration after these dates.

The schedule of studies for each student is made out by the Registration Committee, and the student, after payment of his tuition and fees, is enrolled by the Registrar. No student is admitted to classes without an assignment card from the Registrar's office.

Any change of schedule is made by the Registrar, and after the first week of the term involves a fee of one dollar, unless made at the suggestion of officers of the Institute.

Every student is required to attend all class and assembly exercises for which he is registered, and to satisfy the requirements in each of the subjects in such ways as the instructors may determine.

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 Institute, they are required to return immediately all locker keys, and other Institute property.

It is taken for granted that students enter the Institute with serious purpose. The moral tone is exceptionally good; and the honor system prevails in examinations, and in all student affairs. A student who is known to be exercising a harmful influence on the student life of the Institute may be summarily dismissed, whatever be his scholastic standing.

Scholastic Grading and Requirements

SCHOLASTIC GRADING

The following system of grades is used to indicate the character of the student's work in his various subjects of study:

- 4 denotes Marked Distinction,
- 3 denotes Above Average,
- 2 denotes Average,
- 1 denotes Below Average,
- C denotes Conditioned,
- F denotes Failed,
- inc denotes Incomplete.

In giving the grade *incomplete* the "inc" must be followed by a number indicating the grade of work and by another number in parenthesis indicating approximately the percentage of the work completed. When so reported the grade of "inc" may, in summing grades, be provisionally considered to correspond to such a number of credits as the Registrar shall determine; but if reported without these specifications it shall not be counted. The instructor's reason for giving the grade and the manner by which the incomplete may be removed must be entered in the space provided for that purpose.

When an incomplete is given because of absence from examinations it may be removed by examinations, only if the student has a leave of absence issued by one of the deans and covering the examinations missed.

It is recommended that the grade incomplete be given only in the case of sickness or other emergency which justifies the noncompletion of the work at the usual time.

Conditioned indicates deficiencies other than incomplete that may be made up without actually repeating the subject. A grade of 1 is given when the work is completed. A condition in any term's work must be removed during the next term in residence on the date fixed for the removal of conditions. Each student should consult with his instructor at least a week in advance of this date. Any condition not so removed automatically becomes a failure, unless otherwise recommended by the instructor at the time the condition is given.

Failed means that credit may be secured only by repeating the subject, except that in special cases the Registration Committee may authorize a removal of an "F" by three three-hour examinations.

Term examinations will be held in all subjects unless the instructor in charge of any subject shall arrange otherwise. No student will be exempt from these examinations. Leave of absence from examinations may be obtained only from the Deans, and will be granted only in the case of sickness or other emergency.

SCHOLASTIC REQUIREMENTS

The number of credits allowed for any subject is the number of units multiplied by the grade received. The number of units assigned to any subject in any term corresponds to the total number of hours per week devoted to that subject, including (1) classwork, (2) laboratory, drawing, or field work, and (3) estimated outside preparation. For fulfilling scholastic requirements set forth in the following paragraphs, not less than 90 per cent of the credits required must be received in subjects other than Assembly and Physical Education.

1. Freshmen or sophomore students \dagger who do not receive at least 80 credits at the end of any term will be *placed on probation.**

[†]A student who has transferred to Junior or Senior standing is subject to the same scholastic requirements as are Freshmen and Sophomores until he has satisfactorily completed three full terms of residence at the Institute.

^{*}At the end of the first term of his first year at the Institute a student who has failed to secure 80 credits may be refused registration (instead of being placed on probation), if it has become clear that he has not the qualifications required for the successful prosecution of an engineering or scientific course.

Any student placed on probation must withdraw from student activities or from outside employment, or must reduce the number of subjects he is taking, to a sufficient extent to enable him to meet the requirements. Any such student must report to the Dean of Freshmen in case he is a member of the freshman class, or to the Dean of Upper Classmen in case he is a member of a higher class, before entering upon the work of the ensuing term, and must arrange his schedule of studies and limit his outside activities in accordance with the advice of his Dean.

2. A freshman or sophomore student is *ineligible for registration:* (a) if in the preceding term he did not receive at least 60 credits; (b) if he has already been on probation in any preceding term and did not receive at least 80 credits in the term just completed; (c) if during the preceding school year he did not receive 300 credits (corresponding to an average of 100 credits per term).

3. A student ineligible for registration because of failure to meet the requirements stated in the preceding paragraph may, if he desires, submit immediately to the Registrar a petition for reinstatement, giving any reasons that may exist for his previous unsatisfactory work and stating any new conditions that may lead to better results. Each such application will be considered on its merits. A student so reinstated who again fails to fulfil the scholastic requirements for registration will be granted a second reinstatement only under very exceptional conditions.

4. After a student has completed three full terms of residence at the Institute and has been registered for his Junior year, he shall not be placed on probation nor shall he be refused registration on account of failure to receive a prescribed number of credits during the preceding term or terms.

5. For graduation a student must complete the prescribed work of some one Option of the Course in Engineering or of the Course in Science with an average grade of at least 1.9. 6. At the close of each school-year the Committee on Honor Students awards honor standing to approximately 16 students who have completed the freshman year, and to 12-16 students who have completed the sophomore year. To each of these students is also awarded a prize scholarship carrying half tuition. These awards are based primarily on the scholastic records of the students. Any holder of such a scholarship who in any subsequent term fails to maintain a scholastic standard set by the Committee automatically loses his honor standing and scholarship for the remainder of the school-year.

Honor standing entitles the student to special privileges and opportunities, such as excuse from some of the more routine work, instruction in "honor sections," and admittance to more advanced subjects and to research work. But a student in honor standing may not be admitted to an honor section in a particular subject unless he has obtained a grade of 3 or better in the work prerequisite to that subject.

7. A student will be graduated with honor who has received on the average throughout his course, 145 credits per term, 130 of which result from grades 3 and 4 in subjects other than Physical Education and Assembly, provided also that he maintains such an average through the three terms of the senior year. In addition, a student may be graduated with honor under joint recommendation of his department and the Honors Committee, and approval of the Faculty.

If for any reason a student is carrying less than 40 units, the credits required (as stated in paragraphs 1 and 2 on pages 92-93) shall be prorated on the basis of 40 as a standard. For example, a man carrying 32 units of work shall be expected to obtain four-fifths of 80, or 64 credits, to remain off probation.

Applications for registration in excess of the prescribed number of units, or for less than 25 units, must be approved by the Registration Committee. 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.

Freshmen should make application, shortly before the close of the school year, for admission to the second year of the Course in Engineering or of the Course in Science.

CANDIDACY FOR THE BACHELOR'S DEGREE

A student must file with the Registrar a declaration of his candidacy for the degree of Bachelor of Science on or before the first Monday of December preceding the date at which he expects to receive the degree. His record at the end of that term must show that he is not more than 21 units behind the requirement in the regular work of his course. All subjects required for graduation, with the exception of those for which the candidate is registered during the last term of his study, must be completed by the second Monday of May preceding commencement.

Scholarships and Prizes

FRESHMAN PRIZE SCHOLARSHIPS

Twelve or more freshmen scholarships carrying \$150 or \$300 are awarded by the Institute upon the basis of a competition open to properly qualified male students in the senior classes of high schools or college preparatory schools. A group of competitors for these scholarships is selected by the committee from among the regular candidates for admission who take the spring entrance examinations given by the Institute. There is no special application blank for these scholarships.

The scholarships are awarded on the basis of all the information available in regard to the applicants—the results of their examinations, their high-school records and recommendations, the statements submitted as to their student activities and outside interests, and results of personal interviews. The awards are made without reference to financial need; but any successful student with adequate resources may relinquish the money payment in favor of the next most deserving competitor, while retaining the scholarship as an honorary recognition. The winners of these scholarships are designated Blacker Scholars or Drake Scholars, in recognition of the donors of the scholarship funds, Robert Roe Blacker and Nellie Canfield Blacker, or Mr. and Mrs. A. M. Drake.

DRAKE SCHOLARSHIPS

In addition to the forcegoing, Mr. and Mrs. A. M. Drake of Pasadena have made provision for an annual scholarship available for a graduate of the high schools of St. Paul, Minnesota, and a similar annual scholarship available for a graduate of the high school of Bend, Oregon.

SOPHOMORE AND JUNIOR PRIZE SCHOLARSHIPS

The Institute has established about thirty scholarships known as the Sophomore and Junior Prize Scholarships. These scholarships, which carry half tuition, are awarded at the end of each school-year to those students who as the result of their work, during the freshman and sophomore years, are granted honor standing on the basis described in paragraph 6 on page 94 of this Catalogue. In addition, a smaller number of tuition grants may be awarded to students of high standing who are in need of financial assistance.

It is expected that all students awarded scholarships or tuitiongrants will maintain high scholastic standing. Failure to do so at any time during the school year may result in the termination of the award.

THE CONGER PEACE PRIZE

Everett L. Conger, D.D., for 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 under the direction of the department of English.

Study and Research at the California Institute

PHYSICS

Mathematics, Physics, and Chemistry are universally recognized as the fundamental sciences the development of which has supplied the main-spring of modern civilization. Accordingly, these subjects have been given an outstanding place in the program of the Institute.

Further, since the best education is that which comes from the contact of youth with creative and resourceful minds, the staff of the Norman Bridge Laboratory of Physics has been from the beginning a group of productive physicists rather than merely a group of teachers. The entering freshman makes some contact in his first year with practically all of the members of that staff, and he has the opportunity to maintain that contact throughout his four undergraduate years, and his graduate work as well, if he elects to go on to the higher degrees.

It is the combination of a large graduate school of physics and a limited number of undergraduate students which makes the distinctive feature of the work in physics at the Institute. The instruction is done by the small group method, twenty to a section, save for one rather elaborate demonstration lecture each week throughout the freshman and sophomore years. All of the members of the staff participate in giving these lectures. The undergraduate student who elects physics is usually given opportunity to participate as early as his junior or senior year in some one of the from thirty to sixty researches which are always under way in the laboratory. The average yearly output of the laboratory during the past five years has been from fifty to sixty major papers. There are three general seminars per week, which are regularly attended by all research workers, and all graduate students. In addition there is a weekly theoretical seminar conducted for the benefit of those interested primarily in mathematical physics.

The main outlets for the graduates in physics of the Institute are positions in colleges and universities, and in the increasing number of industrial research laboratories of the country.

MATHEMATICS

Work in pure mathematics leading to the Ph.D. degree was initiated by the Institute in 1926-1927. Candidates for the degree are expected to acquire a reasonable familiarity with some of the major applications of mathematics to the physical sciences. The attention of those intending to take advanced courses in mathematics is particularly directed to the foreign language requirements of mathematical work beyond the Bachelor's degree.

CHEMISTRY AND CHEMICAL ENGINEERING

In the last two years of the Undergraduate Course of Science there are offered to students an Option in Chemistry and an Option in Applied Chemistry. These Options, especially when followed by the Fifth-Year Courses in these subjects, prepare students for positions as teachers and investigators in colleges and universities, as research men in the government service and in industrial laboratories, as chemists in charge of the operation and control of manufacturing processes, and, in the case of the fifth-year Chemical Engineering Course, for the management and development of chemical industries on the chemical engineering side. For students who desire to enter the field of chemical research, for which there are now unusual professional opportunities both on the scientific and applied sides, more specialized study and research leading to the degree of Doctor of Philosophy is provided at the Institute in the fields of inorganic, physical, organic, and biological chemistry.

The character of the instruction in chemistry may be briefly described as follows: The freshman course, which is taken by all students of the Institute, differs much from that usually given in American colleges in that it consists in intensive work in cer-

tain important fields of the subject, rather than in an attempt to give a general survey of the subject, which has been in some measure already afforded by the required high-school course. Thus the freshman work begins with instruction in accurate volumetric analysis, since the student appreciates chemical principles and can effectively deal with their applications in the laboratory only after he has learned to think and work quantitatively. In the first term, along with the volumetric analysis, there are taken up stoichiometry and the principles relating to reactions in aqueous solutions, such as mass-action, solubility effects, neutralization, indicators, strength of acids and bases, hydrolysis of salts, and distribution between phases. The second term is devoted to exact qualitative analysis, where these principles and those relating to oxidation and reduction are further applied to solutions; and the third term is devoted to a laboratory course in selected inorganic preparations and to a survey, in the lectures and class exercises, of descriptive inorganic chemistry.

The second-year work in chemistry, which is taken by all students in the Course in Science, consists on the laboratory side of gravimetric and volumetric, advanced qualitative, and electrometric analysis; but the class work is largely devoted to the discussion of the principles relating to mass-action, the ionic theory, oxidation, and the periodic law. In the second and third terms, and also in the subjects of physical and organic chemistry taken in the later years, the abler students, after a few weeks of introductory work, undertake minor researches in place of the regular work.

The chemical subjects of the junior and senior year consist of courses in physical, advanced inorganic, organic, and applied chemistry. The junior and senior courses in physical chemistry, here known as "Chemical Principles," are not descriptive courses of the usual type; but from beginning to end are presented as a series of problems to be solved by the student. Also in the subjects of organic and applied chemistry problems are a feature. The supervision of the research work of graduate students is distributed among the whole staff of the Division of Chemistry. Each staff member takes charge of only three to five students who desire to work in his special field, so that each student receives a large amount of attention. Thus in physical chemistry the lines of research now being actively pursued by graduate students in cooperation with the staff are: equilibria and freeenergies at high temperatures; reduction-potentials in solution, especially of the rarer elements; the rates of homogeneous gas reactions; the photochemistry of reactions; band spectra in their chemical relations; crystal and molecular structure determined by X-rays and correlated with the newer quantum theories. In organic chemistry the researches in progress deal with problems of isomerism, oxidation, and hydration of unsaturated compounds.

ENGINEERING

Courses are offered at the Institute in Civil, Mcchanical and Electrical Engineering. There are also courses in Aeronautical Engineering and Applied Chemistry, which are described under the respective heads of Aeronautics and Chemistry.

The plan of instruction embodies a four-year course for the degree of Bachelor of Science, and a fifth year of graduate study, quite definitely outlined within the selected field, leading to the degree of Master of Science. Additional work is offered leading to the Ph.D. degree. The Civil, Mechanical and Electrical Engineering groups are not separated until the third year, all following the same program of the fundamental subjects, mathematics, physics and chemistry, supplemented by their general applications in surveying, mechanism, mechanics, strength of materials, direct and alternating currents, heat engines and hydraulics. The divergence between the different branches occurs in the third and fourth years when the study of the professional subjects of specialized nature is introduced. Courses in the HumanitiesEnglish, history, and economics—are included in each year of the curriculum.

The four-year undergraduate courses in engineering are well balanced foundations for entrance into many opportunities within the respective fields. However, those students who wish to prepare for careers in the more intensive technical phases of engineering and have shown capacity to do advanced work are expected to take the fifth year, which represents additional professional subjects and work in both design and research. While the work of the fifth year is prescribed to a considerable extent, it offers time and encouragement for the student to engage in research in a field of his own selection under the guidance of a staff representing a wide range of experience and current activity.

CIVIL ENGINEERING

The branches of Civil Engineering in which advanced work is offered include the control, development and conservation of water; the analysis of structures with particular reference to those types achieving economy through continuity of arrangement; the study of earthquake effects and means of resisting ' them; investigation of stresses in dams and the design of different types of dams; the study of the increasingly important problems of sanitation, sewage treatment and disposal works; the location, design, construction and operation of railroads and highways.

MECHANICAL ENGINEERING

Advanced work in Mechanical Engineering is offered in the following fields: machine design, involving the properties of materials and the processes of production; metallography, the structure of metallic alloys and effects of heat treatment; thermodynamics and power plant design and analysis; internal combustion engines; refrigeration; heating and ventilating; air conditioning; hydrodynamics; and hydraulic machinery.

HYDRAULIC ENGINEERING

Due to the recent establishment of research laboratories at the Institute covering several of the broader fields of hydraulic engineering, both from the hydraulic machinery and the hydraulic structures point of view, the opportunities for advanced study and research in such fields are exceptionally good. The following list of researches are now being carried on in these laboratories in cooperation with the Metropolitan Water District of Southern California, the Los Angeles County Flood Control District, and the Soil Conservation Service of the U. S. Department of Agriculture:

(a) Investigation of the characteristics of high head centrifugal pumps.

(b) Investigation of the velocity distribution in the case and at impeller exit of a centrifugal pump.

(c) Study of friction losses at partial openings of large control valves at high Reynolds' numbers.

(d) Effect of entering velocity distribution upon the coefficient and the performance of Venturi meters with low contraction ratios.

(e) Study of performance characteristics of centrifugal pumps under reverse flow conditions.

(f) Study of friction losses in vane elbows used with liquids.

(g) Study of superelevation in curved channels with supercritical velocities of flow.

(h) Investigation of effect of suspended load on the velocity distribution in channels.

(i) Determination of rate of reduction of bed load in natural streams.

(j) Model studies of economic control of river channels.

ELECTRICAL ENGINEERING

The field of electrical engineering affords opportunity for many choices of life work. Some of these require only the preparation provided in the four-year undergraduate courses, whereas adequate

preparation for the more technical work incident to the design and operation of electrical equipment requires the completion of the five-year course. Still other fields of endeavor call for a knowledge of mathematics, physics, and electrical engineering far in excess of that obtainable in the four- and five-year courses. To meet this need the Institute has provided courses of graduate study and research in electrical engineering which may be taken by students who have completed the five-year engineering course at the Institute, or by students from other colleges who have substantially the same preparation. These courses provide for advanced work in the application of mathematical analysis and physical laws to mechanical and electrical problems incident to electrical design and research, electric transients including lightning phenomena, high voltage production and transmission, electrical engineering problems involving the use of vacuum tubes, and problems relating to the generation and distribution of electrical power for lighting and industrial purposes.

Students desiring to become research men, college teachers or professional experts in electrical engineering may continue their work for the degree of Doctor of Philosophy.

This graduate work in electrical engineering also greatly strengthens the undergraduate courses by bringing students, who feel the five and four-year courses are best adapted to their needs, in close touch with research men and problems, and provides special work for undergraduate students wishing to do a limited amount of research.

AERONAUTICS

With the aid of the Daniel Guggenheim Fund for the Promotion of Aeronautics, the California Institute of Technology has established a Graduate School of Aeronautics and has constructed The Daniel Guggenheim Laboratory of Aeronautics containing a ten-foot, high-speed wind tunnel. This laboratory is under the direction of Dr. Th. von Kármán, who is in charge of the experimental and theoretical researches. The Daniel Guggenheim Fund has also provided funds for the Daniel Guggenheim Airship Institute located at Akron, Ohio, which contains a six-foot wind tunnel and other experimental facilities for lighter-than-air research. There is a close cooperation between the two institutions, the director of the Pasadena laboratory serving as adviser for the Akron Institute.

The following program of instruction and research is now in progress:

1. A comprehensive series of theoretical courses in aerodynamics, hydrodynamics, meteorology, and elasticity, with the underlying mathematics and mechanics, taught by Professors Theodor von Kármán, Harry Bateman, Eric T. Bell, Paul S. Epstein, Beno Gutenberg, Clark B. Millikan, and Arthur L. Klein.

2. A group of practical courses in airplane design conducted by the Institute's experimental staff in cooperation with engineers from the aircraft manufacturing companies in the vicinity.

3. A course in meteorology, with special reference to the problems of weather forecasting for aeronautical operations. The course includes an introduction to modern dynamic meteorology and to the theory and practice of weather forecasting and mapping, using the "air mass analysis" methods.

4. Experimental and theoretical researches on

- (a) the basic problems of flow in real fluids with regard to the scientific foundations of technical hydro- and aerodynamics;
- (b) the basic problems of Applied Mechanics which relate to the properties of materials and the theory of elasticity;
- (c) practical problems in aerodynamics and structures, especially as applied to aeronautics;
- (d) meteorological problems dealing in particular with the properties and behavior of air masses.

The facilities of the Institute are available for students desirous of taking higher degrees, and for qualified workers who wish to carry out researches in the fields detailed above. A few fellowships can be granted to selected men.

As in the older departments of physics, chemistry, and mathematics, emphasis is placed primarily upon the development of graduate study and research; but provision has also been made in the Four-Year Undergraduate Course in Engineering for a definite option leading to such graduate study and research. This affords a broad and thorough preparation in the basic science and engineering upon which aeronautics rests, and includes an introductory survey course in aeronautics in the senior year.

As in the other branches, there are offered in aeronautics definite graduate courses leading to the degree of Master of Science. Since not less than two years of graduate work are required to attain reasonable proficiency in aeronautic design, there is awarded at the end of the first year the degree of "Master of Science for the completion of a Course in Mechanical Engineering" and at the end of the second year, the degree of "Master of Science for the completion of a Course in Aeronautical Engineering." The degree of "Master of Science for the completion of a Course in Meteorology" may be awarded to students completing at least one year of graduate work in this field.

The graduate courses may be taken either by students who have completed a four-year course at the Institute, or by students from other colleges who have had substantially the same preparation. The field of aeronautical engineering is so many-sided that a student who has completed the Undergraduate Course either in Engineering or in Science will be admitted to the Fifth-Year Course. The sixth-year work, however, may be taken only by students who have completed the Fifth-Year Course at the Institute or who have had substantially the same preparation elsewhere. Still more advanced study and research is offered for the degree of Doctor of Philosophy. This degree is given under the same general conditions as those that obtain in the other courses offered at the Institute.

GEOLOGICAL SCIENCES

Through the generosity of Mr. and Mrs. Allan C. Balch, there has been established at the California Institute the Balch Graduate School of the Geological Sciences. The work of this school at the present time comprises the instruction and research being carried on in the various branches of geology, in vertebrate and invertebrate paleontology, in geophysics and geological prospecting, and in seismology, the last named in cooperation with the Carnegie Institution of Washington.

Graduate courses may be taken either by students who have completed the four-year course at the Institute, or by students from other colleges who have substantially the same preparation. Properly qualified graduates from other colleges may also pursue as graduate students the geological studies of the senior year of the undergraduate course.

The curriculum outlined for undergraduate study provides a broad and thorough preparation in the related basic sciences and an introduction to the fundamental principles of geology, paleontology and geophysics. Fifth year courses lead to the degree of Master of Science. During the senior year of the undergraduate course, and throughout the fifth year courses in geology and paleontology, much time will be devoted to investigation, but students desiring to become research men or professional geologists and paleontologists will continue their work at least two years more for the degree of doctor of philosophy. CALIFORNIA INSTITUTE OF TECHNOLOGY

INSTRUCTION IN THE GEOLOGICAL SCIENCES

The elementary geological subjects are given (1) to convey a broad concept of the constitution and structure of the earth, of its origin and history, and of the evolution of life upon it, (2) to afford to engineering students a knowledge of geology required by them in professional practice, and (3) to furnish the basis for advanced work and research in the geological sciences.

Students who complete the Fifth-Year Course in Geology are prepared for geological positions with oil and mining companies and on government and state geological surveys, but further graduate work (leading to the Doctor's degree) is very desirable for those who are preparing themselves for university and museum positions in geology and paleontology and for service as professional geologists.

OPPORTUNITIES FOR RESEARCH IN THE GEOLOGICAL SCIENCES

Within convenient reach of Pasadena occurs an almost unrivaled variety of rock types, geologic structures, and physiographic forms. Field studies can be conducted comfortably throughout the entire year, and this constitutes an important part of the department program.

Stratigraphic and faunal studies may be pursued in the Cenozoic and Mesozoic sedimentary rocks of the Southern Coast Ranges, in which oil fields are located, and in the Mojave Desert region. Thick sections of Paleozoic sediments in southeastern California remain almost unexplored. Structural and physiographic problems in the Coast and Basin Ranges and along the coastal front await critical investigation and frequently involve an interpretation of folding and faulting on a large scale. The presence of many productive oil fields, of large Portland cement plants, and of gem-producing districts in Southern California
afford exceptional opportunities to students interested in economic geology. Moreover, the gold, silver, quicksilver, and copper deposits of the Sierra Nevada and Coast Ranges of California are within comparatively easy reach, and the varied metalliferous deposits of Arizona and Southern Nevada are also available for visit and research.

Researches in geophysics, both theoretical and as applied to prospecting and other structural geology problems, are being prosecuted vigorously, and participation by students in these activities affords extensive instruction in these fields.

Excellent opportunities exist for studies in physical and geological seismology. A fully equipped Seismological Research Laboratory is situated on a site west of the Arroyo Seco in Pasadena. The laboratory is devoted to researches conducted both by the Carnegie Institution of Washington and the California Institute of Technology, and graduate students in the Division of the Geological Sciences will be received in the Laboratory for the purpose of taking part in the researches or of becoming acquainted with seismological methods.

Collections available from many invertebrate and vertebrate faunal horizons in the sedimentary record of western North America permit the student interested in paleontology to secure an intimate knowledge of the history of life. Attractive field and laboratory problems are presented by the sequence, correlation, and ecologic relationships of western faunas, their significance in an interpretation of geologic history, and by the structure, relationships, and evolution of specific groups of fossil organisms.

TEACHING AND RESEARCH FELLOWSHIPS

Fellowships are available for properly qualified students who desire to pursue advanced work in geology, paleontology and geophysics, as in other branches of science; see page 134.

BIOLOGICAL SCIENCES

A department of Biology, rather than the traditional departments of Botany and Zoölogy, has been established, in order to emphasize the unity of the phenomena of living organisms rather than their manifold diversities. That there are many properties common to the two great branches of the living world has become abundantly manifest in recent years. For example, the same principles of heredity that obtain among flowering plants apply also to human traits, and in their response to light, animals and plants conform to common laws of physics. It is true that, at what may be called the biological level, an immense diversity of form and function manifests itself, but enough insight has already been gained to make evident that this diversity is in large part due to permutations and combinations of relatively few fundamental and common properties. It is in the search for these properties that the zoologist and botanist may profitably pool their interests. In the development of modern physiology the fundamental chemical processes in animals, higher plants, yeasts and bacteria are so similar that discoveries in one field elucidate or suggest interpretations in others. The geneticist who works with animals will know only half his subject if he ignores the work on plants, and both plant and animal geneticists will fail to make the most of their opportunities if they overlook the advances in cytology and embryology. It is, then, with the intention of bringing together in sympathetic union a group of investigators whose interests lie in the fundamental aspects of their subjects, that a department of Biology has been organized.

As in the other departments of the Institute, emphasis is placed primarily on research and graduate study; and, even in these directions, no attempt is made to cover at once the whole science of biology, but rather efforts are concentrated on the development of those of its branches which seem to offer the greatest promise as fields of research. It is proposed to organize groups of investigators in general physiology, biophysics, biochemistry, genetics and experimental embryology. The choice of these fields of modern research implies that emphasis will be laid on the intimate relations of biology to the physical sciences. That a closer association of these sciences with biology is imperative is becoming more and more apparent as indicated by the development of special institutes for such work.

An experimental farm for plant genetics has been established near the Institute; a special laboratory, equipped for work in plant physiology, has been built; and the marine station at Newport Bay gives an opportunity for work in experimental embryology and biology.

ASTROPHYSICS

The General Education Board has provided for the construction by the Institute of an Astrophysical Observatory, equipped with a 200-inch reflecting telescope and many auxiliary instruments. A prime purpose of the gift is to secure for the new Observatory the advantage, in its design, construction, and operation, of the combined knowledge and experience of the strong group of investigators in the research laboratories of the Institute and in the neighboring Mount Wilson Observatory of the Carnegie Institution of Washington. Such cooperation has been cordially promised by the President of the Carnegie Institution with the approval of its Executive Committee and of the director of the Mount Wilson Observatory and his associates. Formal approval was thus given to the continuation and extension of the cooperation which has been in progress between the California Institute and the Mount Wilson Observatory for several years, especially in the study of the astronomical, physical, and chemical aspects of the constitution of matter.

The purpose of the Astrophysical Observatory is thus to supplement, not to duplicate, the Mount Wilson Observatory. The increased light-collecting power of the 200-inch telescope will permit further studies of the size, structure and motion of the galactic system; of the distance, motion, radiation, and evolution of stars; of the spectra of the brighter stars under very high dispersion; of the distance, motion, and nature of remote nebulæ; and of many phenomena bearing directly on the constitution of matter.

The new observatory will consist of two main features. One of these will be the 20Q-inch telescope, with its building, dome, and auxiliary equipment, to be erected on the most favorable high-altitude site that can be found within effective working distance of the associated groups of investigators and their extensive scientific equipment. The other will be an Astrophysical Laboratory located on the Institute campus, which will serve as the headquarters in Pasadena of the Observatory Staff and of the Graduate School of Astrophysics. Its equipment will include instruments and apparatus for the measurement of photographs, the reduction and discussion of observations, and for such astrophysical investigations as can be made there to the best advantage. Its instruments for the interpretation of astrophysical phenomena will be designed to supplement those of the laboratories of the Institute and the Pasadena laboratory of the Mount Wilson Observatory. Well-equipped shops for the development of new instruments have been erected on the campus, and the Astrophysical Laboratory has been completed, though some of its chief instruments are still in process of construction.

The value of a telescope depends as much upon the efficiency of the instruments and apparatus used to receive, record, and interpret celestial images as upon its optical and mechanical perfection and its light-collecting power. In the present plan, especial emphasis is therefore laid upon the development of all forms of auxiliary apparatus, such as spectrographs and their optical parts; photographic plates of the various types required for astrophysical and spectroscopic research; radiometers, thermocouples, and photoelectric cells; recording microphotometers and other forms of measuring machines; and laboratory apparatus for reproducing or interpreting celestial phenomena.

An Observatory Council, comprising four members of the Executive Council of the Institute, and also including Dr. Walter S. Adams, has been placed by the trustees in full charge of the design, construction, and operation of the Astrophysical Observatory and Laboratory. With the approval of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed by the Observatory Council as its Executive Officer, in direct charge of design and construction. An Advisory Committee, including the Director and Assistant Director of the Mount Wilson Observatory and many other prominent men of science, aid the Observatory Council in determining matters of policy. The organization of the Observatory Council and the personnel of its Advisory Committee are shown on page 51 of this Catalogue.

Any great increase in the size of telescopes requires a long study of the most promising methods of making large paraboloidal mirrors. A new form of Pyrex glass has been chosen as the best available material, after much experimental work, and it is hoped that the rough disk for the 200-inch mirror, which was cast last year at the Corning Glass Works, will be shipped to Pasadena in January. A 120-inch Pyrex mirror, cast in 1934, is now being ground and figured in the Optical Shop.

The extensive investigation of primary and auxiliary instruments, which forms such a vital part of the general scheme, has also made marked progress, through the active cooperation of many leading men of science and engineers. Microphotometers, radiometers, photo-electric cells and other instruments of various types have been carefully studied and tested in difficult research problems. The Research Laboratory of the Eastman Kodak Company has generously agreed to deal with many of the special photographic problems. The short focus spectrograph objective devised by Rayton has greatly increased the range of the 100-inch telescope and made possible the recent researches of Hubble and Humason on the expanding universe. A new objective of still shorter focal length has been completed by Beck after the design of the British Scientific Research Association, and successfully tested on Mount Wilson. A very advantageous method of coating telescope mirrors with aluminum instead of silver has been applied by Dr. John Strong to several large mirrors, including that of the 36-inch Crossley reflector on Mount Hamilton and the 60-inch and 100-inch reflectors on Mount Wilson. A site for the 200-inch telescope has been purchased on the summit of Palomar Mountain, and water and oil tanks and several buildings have been erected there.

It is expected that, after the Astrophysical Laboratory on the campus has been completely equipped, the Institute will offer to competent students the opportunity of pursuing advanced courses of study and research in astrophysics, leading to the degrees of Master of Science and Doctor of Philosophy. Undergraduate students who desire to prepare themselves for such graduate work should take the Physics Option of the Course in Science.

It should be remembered that the number of positions open to able young men well trained in astrophysics and its related subjects is small. For this reason only those exceptionally well qualified for such work should undertake graduate study and research.

THE HUMANITIES

One of the distinctive features of the California Institute is its emphasis upon the humanistic side of the curriculum. In the degree and genuineness of this emphasis the Institute has differentiated itself from other American schools of science, most of which accord little more than a gesture of recognition to the liberal arts. As a rule, in schools of engineering, the professional studies monopolize nearly all the available time and money, ' leaving the humanities to take what is left, which usually turns out to be very little.

This has been particularly unfortunate. It has recruited into the engineering profession large numbers of young men with inadequate cultural backgrounds, lacking in social sympathy, in breadth of outlook, and in their acquaintance with those imponderable forces which even engineers have to take into account. It has crowded into the lower ranks of the engineering vocation too many unimaginative routineers who get no farther than the drafting-room. That should not be the case, for there is no good reason why engineers should be more limited in their intellectual versatility, or in the range of their human interests, than men of any other profession. Many of them are not. On the contrary, there are those who have shown, time and again, that scientific erudition can be illuminated by humanism, and technical skill vivified by imagination. It is to men of this type that the world must continue to look for leadership in all branches of science, and it is to the training of such men that the energies of the California Institute are primarily directed.

Hence the Institute, from the very outset, has recognized the desirability of making a place in its undergraduate curriculum for a generous amount of instruction in the humanities. The faculty, in thorough sympathy with this aim, has cooperated by eliminating some of the more specialized technical subjects commonly included in undergraduate engineering courses. As a result, it has been found possible to require every student to take, in each of his four undergraduate years, at least one course of a humanistic character. These courses in the Division of the Humanities cover the field of English and Foreign Literatures, European and American History, Philosophy and Social Ethics, Economics and Government. All of them are so planned and articulated that the student obtains a solid grounding, and not merely the superficial acquaintance which is too often the outcome of a free elective system. The standards of intellectual performance in these studies are maintained on the same plane

as in the professional subjects. Every effort is made to impress upon undergraduates the fact that there is an essential unity to all knowledge, and that no man can master science if he sets out to master science only. The history of human achievement has but a single page.

One of the largest and most attractive buildings on the Institute campus is devoted to the work in Literature, Languages, Philosophy, Economics, History, and Government. This Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. In connection with the acceptance of this gift, a special endowment fund of \$400,000 was raised for the support of instruction in the humanistic fields, this amount being subscribed by several friends of the Institute.

In addition to the regular staff of the Institute, several scholars from other institutions are giving instruction in the Division of the Humanities during the current year. Among these are Professor Merle E. Curti of Smith College, Professor Godfrey Davies, formerly of the University of Chicago, Professor Louis B. Wright, formerly of the University of North Carolina, Professor Hardin Craig of Stanford University and Professor Frederick M. Padelford of the University of Washington. It is anticipated that with the opportunities for research in English Literature and American History which are afforded by the proximity of the Huntington Library, the instruction given at the Institute in these fields will be steadily strengthened by the association of visiting scholars.

Information and Regulations for the Guidance of Graduate Students

A. GENERAL REGULATIONS

I. REQUIREMENTS FOR ADMISSION TO GRADUATE STANDING

1. The Institute offers graduate work leading to two higher degrees, the degree of Master of Science, and the degree of Doctor of Philosophy. To be admitted to graduate standing at the Institute an applicant must in general have received a Bachelor's degree representing the completion of an undergraduate course in science or engineering substantially equivalent to one of those courses offered by the Institute. He must, moreover, have attained such a scholastic record and, if from another institution, must present such recommendations as indicate that he is fitted to pursue with distinction advanced study and research.

2. Application for admission to graduate standing at the Institute for work toward either the Master's or the Doctor's degree should be made upon a form which can be obtained from the Registrar. The applicant should state the degree for which he wishes to work. If the applicant's preliminary training in science, mathematics, and engineering has not been substantially that given by the four-year undergraduate courses at the Institute, he must pursue such undergraduate subjects as may be assigned. Since admission to graduate work will be granted to only a limited number of students of superior ability, applications should be made as long as possible before the opening of the school year, preferably by the first of March. Students applying for assistantships or fellowships need not make separate application for admission to graduate standing. See Section DI.

3. Admission to graduate standing does not of itself admit to candidacy for the degree of Master of Science or Doctor of Philosophy. As to this, see pages 118, 120, 127, 130.

II. TUITION FEES

In the school year 1934-35 and thereafter the tuition fee for graduate students pursuing courses of more than 32 units will be \$300 a year, payable in three equal installments of \$100 at the beginning of each term.^{*} Graduate students who continue their researches during the summer are not required to pay tuition fees therefor.

An annual fee of \$3 to assist in the defraying of expenses in cases of emergency requiring hospitalization is required.** No other fees are required of graduate students; but charges may be made for breakage and supplies. Students working in the chemical laboratories are required to make a deposit of \$15 at the beginning of the school year to cover these charges. No degrees are awarded until all bills due the Institute have been paid.

In regard to fellowships and assistantships, see page 134 of this Catalogue. In addition, to students with high scholastic attainments there may be awarded *graduate scholarships* covering onehalf or the whole of the tuition fee. For such students *loans* also may be arranged, for which application should be made to the Student-Aid Committee.

B. REGULATIONS AND REQUIREMENTS CONCERNING WORK FOR THE DEGREE OF MASTER OF SCIENCE

I. GENERAL REQUIREMENTS

To receive the degree of Master of Science, the student must complete in a satisfactory way the work indicated in the schedule of one of the Fifth-Year Courses, as well as in the schedule of the Four-Year Course in Science or in Engineering (see pages 155-158), except that in the case of students transferring from other institutions equivalents will be accepted in subjects in which the student shows by examination or otherwise that he is

^{*}Except that the tuition fees of students who began their graduate work at the Institute prior to September, 1933, and have since been continuously in residence will be at the rates described in the 1932 Catalogue.

^{**}See page 86.

proficient, and except in so far as substitutions may be approved by special vote of the Committee in charge.

Senior students at the Institute desiring to return for a fifth year will file an application with the representative of the department in which they expect to do their major work, and such application will be passed upon by the Engineering or the Science Course Committee. Such students will be expected to present satisfactory scholarship qualifications, and to have demonstrated a capacity for doing advanced work.

All programs of study, and applications for candidacy for the degree of Master of Science, shall be in charge of the Committee on Courses in Science (in case the advanced work is to be in Physics, Chemistry, Chemical Engineering, Mathematics, Geology, Paleontology, or Biology), or of the Committee on Courses in Engineering (in case the work is to be in Civil, Mechanical, Electrical, or Aeronautical Engineering); and recommendations to the Faculty for the award of that degree shall be made by one of these Committees, all such actions being taken in general after consideration and recommendation by the department concerned.

A student before entering upon work for the degree of Master of Science should, after consultation with the department concerned, submit a plan of study (together with his previous record if he transfers from another institution), and make application to the Committee in charge for acceptance as a candidate for that degree. Application forms for admission to candidacy for the degree of Master of Science may be obtained from the Registrar, and must be submitted not later than the end of the first week of the first term of the year in which the degree is to be granted.

II. REGISTRATION

1. The regulations governing registration and student responsibilities as given for undergraduate students on page 90 of the Catalogue apply also to Fifth-Year students. CALIFORNIA INSTITUTE OF TECHNOLOGY

2. Before registering, the graduate student should consult with members of the department in which he is taking his work to determine the studies which he can pursue to the best advantage.

3. A student will not receive credit for a course unless he is properly registered, and at the first meeting of each class should furnish the instructor with a regular assignment card for the course, obtained from the Registrar's office.

4. Applications for registration in excess of the prescribed number of units must be approved by the Committee on Courses in Science or by the Committee on Courses in Engineering and will be conditioned upon the quality of work done in the preceding term.

III. SCHOLASTIC REQUIREMENTS

1. Scholastic Requirements given on page 92 of the Catalogue for undergraduate students, with the exception of paragraphs 5 and 6, also apply to Fifth-Year students.

2. In the case of a student registered for a Master's Degree and holding an Assistantship or Teaching Fellowship, the actual number of hours per week required by the teaching shall be deducted from the total number of units for which the student may register.

IV. THESIS

In the Division of Geology and Paleontology, a complete first draft of theses presented in partial fulfillment of the requirements for the degree of Master of Science must be submitted to the supervising instructor by the first of May. Two final copies of theses must be filed with the Division by the first of June.

C. REGULATIONS CONCERNING WORK FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

I. GENERAL REGULATIONS

The degree of Doctor of Philosophy is conferred by the Institute in recognition of breadth of scientific attainment and of power to investigate scientific problems independently and efficiently, rather than for the completion of definite courses of study through a stated term of residence. The work for the degree must consist of scientific research and the preparation of a thesis describing it, and of systematic studies of an advanced character in science or engineering. In addition, the candidate must have acquired the power of expressing himself clearly and forcefully both orally and in written language, and he must have a good reading knowledge of French and German.

Subject to the general supervision of the Committee on Graduate Study, the student's work for the degree of Doctor of Philosophy is specifically directed by the department in which he has chosen his major subject. Each student should consult his department concerning special divisional and departmental requirements. See Section VI for special requirements for the Doctor's degree in Mathematics, Physics and Electrical Engineering, Section VII for special requirements in Chemistry, Section VIII for special requirements in Chemistry, Section VIII for special requirements in Aeronautics, Civil and Mechanical Engineering.

With the approval of the Committee on Graduate Study, any student studying for the doctor's degree whose work is not satisfactory may be refused registration at the beginning of any term by the department in which the student is doing his major work.

II. REQUIREMENTS FOR ADMISSION TO WORK FOR THE DOCTOR'S DEGREE

With the approval of the Committee on Graduate Study, students are admitted to graduate standing by the department in which they choose their major work toward the Doctor's degree. In the case of insufficient preparation, applicants for the Doctor's degree may be required to register for the Master's degree first. The Master's degree, however, is in no sense a prerequisite for the Doctor's degree.

III. REGISTRATION

1. Students are required to register and file a program card in the Registrar's office at the beginning of each term of residence, whether they are attending regular courses of study, or only carrying on research or independent reading, or writing a thesis or other dissertation.

2. Before registering, the student should consult with members of the department in which he is taking his major work to determine the studies which he can pursue to the best advantage.

3. A student will not receive credit for a course unless he is properly registered, and at the first meeting of each class should furnish the instructor with a regular assignment card for the course, obtained from the Registrar's office. The student himself is charged with the responsibility of making certain that all grades to which he is entitled have been recorded.

4. One term of residence shall consist of one term's work of not less than 45 units of advanced work in which a passing grade is recorded. If less than 45 units are successfully carried the residence will be regarded as shortened in the same ratio, but the completion of a larger number of units in any one term will not be regarded as increasing the residence. Students who are permitted to carry on research during the summer will be allowed credit, but in order to obtain such credit they must register therefor in advance.

5. The number of units allowed for a course of study or for research is figured on the basis that one unit corresponds roughly to one hour a week of work throughout the term.

6. In registering for research, students should indicate on their program card the name of the instructor in charge, and should consult with him to determine the number of units to which the proposed work corresponds. At the end of the term the instructor in charge shall decrease the number of units for which credit is given, in case he feels that the progress of the research does not justify the full number originally registered. 7. Graduate students studying for the Doctor's degree who are devoting their whole time to their studies will be allowed to register for not more than 60 units in any one term. Students on part time teaching appointments will not be allowed to register for so many units. Teaching Fellows and Assistants will be allowed to register for not more than 45 units.

IV. GRADES IN GRADUATE COURSES

1. Term examinations are held in all graduate courses unless the instructor shall, after consultation with the chairman of the division, arrange otherwise. No student taking a course for credit shall be exempt from these examinations when held.

2. Grades for all graduate work are reported to the Registrar's office at the close of each term.

3. The following system of grades is used to indicate class standing in graduate courses: 4 denotes marked distinction, 3 denotes above average, 2 denotes average, 1 denotes below average, C denotes conditioned, F denotes failed. In addition to these grades, which are to be interpreted as having the same significance as for undergraduate courses, the grade P, which denotes passed, may be used at the discretion of the instructor, in the case of seminar, research, or other work which does not lend itself to more specific grading.

V. REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

1. Major and Minor Subjects. The work for the Doctor's degree must consist of scientific research and advanced studies in some branch of science or engineering, which will be termed the "major subject" of the candidate. In addition, as "minor subject" (or subjects), studies which will give a fundamental knowledge and research point of view must be pursued in at least one other branch of science or engineering.

The choice and scope of the minor subject must be approved by the departments in charge both of the major and minor subjeets, and must involve not less than 45 units of advanced study in each minor subject. Such advanced study must consist primarily of courses which are listed as graduate courses. With the approval of the departments concerned, however, selected undergraduate courses of an advanced character may also be counted toward the minor, with an appropriate reduction in the number of units allowed.

2. Residence: At least three years of work in residence subsequent to a baccalaureate degree equivalent to that given by the Institute are required for the Doctor's degree. Of this at least one year must be in residence at the Institute. It should be understood that these are minimum requirements, and students must usually count on spending a somewhat longer time in residence.

Graduate students are encouraged to continue their research during the whole or a part of the summer, but in order that such work may count in fulfillment of the residence requirements, the student must comply with the above regulations and file a registration card for such summer work in the office of the Registrar.

A graduate student who, by special arrangement, is permitted to conduct a portion of his research in the field, in government laboratories, or elsewhere off the campus, must file a registration card for this work in the office of the Registrar, in order that it may count in fulfilment of residence requirements. The number of units to be credited for such work shall be determined by the Dean of the Graduate School in consultation with the Chairman of the Division in which the student is carrying his major work; and a recommendation as to the proportion of the full tuition to be paid for such work shall be made by the Dean to the Executive Council.

A student whose undergraduate work has been insufficient in amount or too narrowly specialized, or whose preparation in his special field is inadequate, must count upon spending increased time in work for the degree.

124

3. Admission to Candidacy: Any student admitted to work for the Doctor's degree who has been in residence one term or more, who has satisfied the several departments concerned by written or oral examination or otherwise that he has a comprehensive grasp of his major and minor subjects as well as of subjects fundamental to them, who has satisfied the department of modern languages that he can read scientific German and French with reasonable facility, who has shown ability in carrying on research and whose research subject has been approved by the Chairman of the Division concerned, and whose program of study has been approved by both his major and minor departments may, on recommendation of the Chairman of the Division in which he is working, be admitted by the Committee on Graduate Study to candidacy for the degree of Doctor of Philosophy. Members of the permanent Institute staff of rank higher than that of Assistant Professor are not admitted to candidacy for a higher degree.

A regular form is provided for making application for admission to candidacy. This form may be obtained from the Dean of the Graduate School, and the application must be on file in the office of the Registrar before the close of the first term of the year in which the degree is to be conferred. The student himself is responsible for seeing that admission is secured at the proper time.

4. Examinations: The French and German examinations, prerequisite to admission to candidacy for the degree of Doctor of Philosophy, will be given in September on the afternoon of the date set for the removal of conditions, and on the afternoons of the first Fridays of December and of March. Candidates may, in place of the above, take the advanced undergraduate examinations offered at the end of each term. Students who have credit for courses in languages taken at the Institute and who have a grade above average may be exempted from further requirement after consultation with the language department. Graduate students are permitted to audit all courses in the department of languages. In general, however, it is desirable for students without previous language study to take the class work in French and German for at least the first term rather than to depend upon studying it by themselves. Students expecting to file application for candidacy in December are advised to take the September examination, so that, if their preparation is inadequate, they may enroll for the fall term in one of the language courses. No fee is charged for these examinations.

Special examinations, or the final examinations in specified courses, are required by certain departments for admission to candidacy for the Doctor's degree. (See Sections VI, VII, VIII and IX.)

Final examinations in their major and minor subjects are required of all candidates for the Doctor's degree. These examinations, subject to the approval of the Committee on Graduate Study, may be taken at such time after admission to candidacy as the candidate is prepared, except that they must take place at least two weeks before the degree is to be conferred. The examinations may be written or oral, or both, and may be divided into parts or given all at one time at the discretion of the departments concerned. The student must petition for these examinations on a form obtained from the Dean of the Graduate School after consultation with the Division Chairman.

5. Thesis: The candidate is required to submit to the Dean of the Graduate School two weeks before the degree is to be conferred two copies of a satisfactory thesis describing his research, including a one-page digest or summary of the main results obtained.

With the approval of the department concerned, a portion of the thesis may consist of one or more articles published jointly by the candidate and members of the Institute staff or others. In any case, however, a substantial portion of the thesis must be the candidate's own exposition of his work.

The thesis must be typewritten on paper of good quality, $8\frac{1}{2}$ by 11 inches, leaving a margin for binding of not less than one inch, or may consist in part of pages taken from a published article and pasted on paper of the above size. It should be preceded by a title page containing the following items: Title, Thesis by (name of candidate), In Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, California Institute of Technology, Pasadena, California, Date (year only).

Before submitting his thesis to the Dean of the Graduate School, the candidate must obtain approval of it by the Chairman of his Division, and the members of his examining committee. This approval must be obtained in writing on a form which will be furnished at the office of the Dean. The candidate himself is responsible for allowing sufficient time for the members of his committee to examine his thesis.

6. Grades on Degree: The Doctor's degree is awarded with the designations "summa cum laude," "magna cum laude," "cum laude," or without designation.

VI. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN MATHEMATICS, PHYSICS, AND ELECTRICAL ENGINEERING

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in Section V, the Division of Mathematics, Physics and Electrical Engineering has adopted the following supplementary regulations:

1, a. To be recommended for candidacy for the Doctor's de-

gree in *Mathematics* the applicant must pass the following courses with a grade of 2 or better:

Ma. 101 a b c	Modern Algebra (including Galois Theory)
Ma. 201	Modern Analysis
Ma. 256	Modern Differential Geometry
Ma, 102	Introduction to Higher Geometry

and any one of the courses, other than the purely mathematical, listed under requirements for admission to candidacy in Physics, preferably one of the following:

> Ph. 101 a b c Electricity and Magnetism Ph. 103 a b c Analytical Mechanics

1, b. To be recommended for the candidacy for the Doctor's degree in *Physics* the applicant must pass the following courses with a grade of 2 or better:

Ph. 101 a b	Electricity and Magnetism
Ph. 103 a b	Analytical Mechanics
Ph: 105 a b	Opties
Ph. 107 a b c	Atomic Physics

and any two of the following courses:

Ph. 101 c	Electricity and Magnetism
Ph. 103 c	Analytical Mechanics
Ph. 114	Principles of Quantum Mechanics
Ph. 115	Applications of Quantum Mechanics

and, in case the applicant's minor is in Mathematics, one of the following courses:

Ma. 8 a b c	Advanced Calculus
Ma. 10 a b c	Differential Equations
Ма. 114 а b с	Mathematical Analysis

and, in case the applicant's minor is in Chemistry, the following course: Ch. 21 a b c Chemical Principles

1, c. To be recommended for candidacy for the Doctor's degree in *Electrical Engineering* the applicant must pass the following courses with a grade of 2 or better:

Ph. 101 a b c Electricity and Magnetism

and one of the following courses:

Ph. 103 a b c Analytical Mechanics AM. 1 a b Applied Mechanics together with AM. 11 c Strength of Materials

and one of the following courses:

	Ma, 8 a b c	Advanced Calculus
	Ph.5abc	Introduction to Mathematical Physics
ſ	Ma, 8 a b	Advanced Calculus
	together with	
l	Ma. 11	Differential Equations

and the following courses or their equivalents:

EE. 120 Alternating Curi	ent Analysis
EE.122 Advanced Altern	ating Current Machinery
EE. 144 Transmission Lin	nes
EE. 152 Dielectrics	
EE. 162 Vacuum Tubes	

2. An applicant may also satisfy the requirements described above by taking an examination in the subject with the instructor in charge.

Students are advised to satisfy the conditions for admission to candidacy in their respective departments as rapidly as possible.

Students who fail to meet at least one-half of these requirements by the end of their first year of graduate study will not be allowed to register for further work except when special permission is obtained from the department.

3. In general a student will find it necessary to continue his graduate study and research for two years after admission to candidacy.

4. A candidate for the degree of Doctor of Philosophy with a major in mathematics must deliver a typewritten or printed copy of his completed thesis, in final form, to the professor in charge on or before May 1st of the year in which the degree is to be conferred.

5. A student in Electrical Engineering will, in general, be expected to have had six months or more of practical work in manufacturing, operating, or engineering research, in addition to the time required for college residence. CALIFORNIA INSTITUTE OF TECHNOLOGY

VII. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN CHEMISTRY

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in , Section V, the Division of Chemistry has adopted the following supplementary regulations:

1. To be recommended for candidacy for the Doctor's degree the applicant must give satisfactory evidence of proficiency by means of the following:

- a. Candidacy examination in physical chemistry,
- b. Candidacy examination in inorganic chemistry,
- c. Candidacy examination in organic chemistry,
- d. Candidacy examination in colloid and surface chemistry,
- e. Written report on the progress of research.

The examinations will be mainly written but will be partly oral. They will cover their respective subjects substantially to the extent that these are treated in the Undergraduate Chemistry Option; the proficiency expected is not less than that required by the abler undergraduates. A detailed informational knowledge is not so much desired as an understanding of general principles and a power to apply these to concrete problems.

The written report must be a satisfactory description of the applicant's research up to the date of his application. By this report and his laboratory work the applicant must have given evidence of his industry and ability in research, and of his power to present his results in clear, forceful language and with discrimination as to what is essential in scientific papers.

2. It is expected that the applicant shall have studied mathematics and physics substantially to the extent that these subjects are covered in the first two years of the Institute Undergraduate Courses. In cases where the applicant's training is less extensive than this, the Division of Chemistry may prescribe additional work in these subjects prior to recommending him as candidate.

3. After admission to candidacy students must in general pursue advanced study and research for not less than 5 terms (counting equivalent summer work) before they will be recommended by the Division of Chemistry for the final examination for the Doctor's degree.

4. The final examination will consist in part of the candidate's oral presentation of a brief resume of his research and its defense against attack, and in part of the defense of a set of propositions prepared by the candidate. The candidate may also expect questions not immediately related to his research or propositions.

The propositions should be about twelve in number, of which about three should relate to the minor subject, three (or more) to general branches of chemistry, and about six to the branch of chemistry of major interest to the candidate, including his research. The candidate may also include propositions not relating to his major and minor fields. The propositions, prepared by the candidate himself, should display his originality, breadth of interest, and soundness of training; the candidate will be judged on his selection and formulation of the propositions as well as on his defence of them.

A copy of the set of propositions must be submitted to the Division of Chemistry at least two weeks before the date set for the examination. A copy of the set of propositions must be submitted to the Dean of the Graduate School with each of the two copies of the thesis.

5. The Doctor's degree is not awarded in Chemical Engineering at the present time, but students interested in this field may offer a minor in Chemical Engineering in connection with a major in Chemistry or in Mechanical Engineering.

VIII. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN THE DIVISION OF GEOLOGY AND PALEONTOLOGY

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in Section V, the Division of Geology and Paleontology has adopted the following supplementary regulations:

1. To be admitted to candidacy for the Doctor's Degree in the Division of Geology and Paleontology the applicant must have shown more than average ability in mastering the previous geological and paleontological subjects.

2. The applicant for admission to candidacy may be required to take a qualifying examination which may be oral, or written, or both.

3. Students who have not been admitted to candidacy before the end of their second year of graduate study at the Institute will not be permitted to register for further work.

4. After admission to candidacy, students must in general pursue advanced study and research for a minimum of six terms, or approximately two years (counting each summer of field work as a term).

5. Candidates are required to take two oral examinations after admission to candidacy. The first, termed the General Examination, tests knowledge in a specified number, but not all, of the various branches of geology and paleontology, and may be taken at any convenient time after admission to candidacy. The second, or Final Examination, is principally, but not entirely, a defense of the Ph.D. thesis and a test of the candidate's knowledge in the specialized fields of his major and minor subjects.

6. A first draft of the Ph.D. thesis with data, maps, and illustrations complete must be submitted to the professor in charge not later than February 1st. Two copies of the final, revised thesis must be filed by April 20th with the professor in charge and circulated among the members of the examining committee. Likewise on this date, the candidate must file and circulate a paper, prepared for publication in form acceptable to his examining committee, embodying the results of his research in whole or in part.

IX. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN AERO-NAUTICS, CIVIL AND MECHANICAL ENGINEERING

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as stated in Section V, the Division of Civil and Mechanical Engineering has adopted the following supplementary regulations:

1, a. To be recommended for candidacy for the Doctor's degree in *Aeronautics* the applicant must pass the following courses with a grade of 2 or better:

Ma. 14 Vector Analysis AE. 251 a b c Aerodynamics of the Airplane Theoretical Aerodynamics I AE. 266 a b and one of the following: Ma. 109 a b Introduction to Mathematical Analysis **Engineering Mathematical Physics** EE. 226 a b and also one of the following: AE. 252 a b c Airplane Design Analytical Mechanics Ph. 103 a b c AE. 270 a b c Elasticity Applied to Aeronautics

If any of the above subjects were taken elsewhere than at the Institute, the candidate will be required to pass special examinations indicating an equivalent knowledge of the subject.

1, b. To be recommended for candidacy for the Doctor's degree in *Civil Engineering* the applicant must pass the courses prescribed and elected for the fifth year, or equivalent substitutions satisfactory to the department, and such other advanced courses as the department may require, and must pass special comprehensive oral or written examinations in the fields covered by these courses. CALIFORNIA INSTITUTE OF TECHNOLOGY

1, c. To be recommended for candidacy for the Doctor's degree in *Mechanical Engineering* the applicant must pass the following courses with a grade of 2 or better:

	Ma. 11 EE. 226 a b	Differential Equations Engineering Mathematical Physics
and one	of the following Ma. 8 a b c Ma. 15 a b c	: Advanced Calculus Higher Mathematics for Engineers and Physicists
and any	one of the follo (ME, 101 a b ME, 110 a b c ME, 111 a b c AE, 270 a	wing three groups: Advanced Machine Design Science of Metals Metallography Laboratory Elasticity Applied to Aeronautics
	$\left\{\begin{array}{l} {\rm ME.~120,122}\\ {\rm 122}\\ {\rm Ph.~211} \end{array}\right.$	Heat Engines Thermodynamics
	Hy. 100 Hy. 101 A.E. 266 a b and 267	Applied Hydrodynamics Hydraulic Machinery Theoretical Aerodynamics
	and also spe examinations	cial comprehensive oral or written in the fields covered by these courses.

2. In general a student will find it necessary to continue his graduate study and research for two years after admission to candidacy, and will be expected to have had six months or more of practical work.

D. OPPORTUNITIES FOR GRADUATE AND SCIENTIFIC WORK AT THE INSTITUTE

I. FELLOWSHIPS AND ASSISTANTSHIPS

The Institute offers in each of its Divisions a number of Fellowships and Graduate Assistantships. These usually carry as stipends tuition (\$300) with or without an additional grant.

Most of the major grants consist in providing, for a continuous period of ten months, board in the Athenæum (see pages 74 and 134) and lodging in the Athenæum loggia, the dormitory, or student houses. The purpose of this plan is to enable the Fellows and Assistants of the various Divisions to live together under attractive and healthful conditions, and thus secure the great educational and social advantages that result from intimate contacts with one another, with members of the professorial staff of the Institute, and with others using the Athenæum.

. In the award of graduate scholarships and fellowships preferred consideration will be given to students who have been accepted as candidates for the Ph.D. degree.

Teaching Fellows and Graduate Assistants devote during the school year not more than fifteen hours a week to teaching or laboratory assistance of a character that affords them useful experience. This time includes that required in preparation and in marking note-books and papers, as well as that spent in classroom and laboratory. Of the remaining time at least one-half must be devoted to research, unless otherwise arranged by the Division concerned; and the obligation to prosecute the research earnestly is regarded as no less binding than that of showing proper interest in the teaching and in the advanced study, which is also pursued so far as time permits. The appointments are for a period of ten months; and it is understood that the research work will be continued in the summer, at least until this period is completed.

Forms for making application for Fellowships or Assistantships may be obtained on request from the Dean of the Graduate School. When possible, these applications should reach the Institute before March 1st, and notices of awards will be mailed to successful applicants on March 20th. Appointments to Fellowships and Assistantships are for one year only; and a new application must be filed before March 1st of each year by all who desire appointments for the following year, regardless of whether they are already holders of such appointments or not.

II. RESEARCH FELLOWSHIPS

1. Institute Research Fellowships: The Institute each year appoints as Research Fellows a number of men holding the

degree of Doctor of Philosophy who desire to pursue additional research work.

2. The National Research Fellowships established by the Rockefeller Foundation are awarded by the National Research Council to men who have their Doctor's degree. Fellows may choose the institution in which they desire to pursue research. Applications should be made to the National Research Council, Washington, D. C.

3. The American Petroleum Institute is supporting the work of several Research Fellows at the California Institute. The researches of these Fellows relate to fundamental properties of petroleum and natural gas.

4. The Inspiration Consolidated Copper Company has provided a fund for research on certain phases of the copper leaching process.

III. INSTITUTE GUESTS

Members of the faculties of other educational institutions and Research Fellows who have already received their Doctor's degree and desire to carry on special investigations may be granted the privileges of the facilities of the Institute, without payment of fees. Arrangement should be made in advance with the Chairman of the Division of the Institute concerned. Such guests are requested to file a card in the Registrar's office at the beginning of their work, giving Institute and home address, degrees, nature of work planned, etc.

IV. GRADUATE LIFE

The Athenæum (see page 74) affords opportunity for contact between the Associates of the Institute, distinguished foreign visitors, and members of the staffs and graduate students at the three adjacent institutions, the Mount Wilson Observatory, the Huntington Library, and the California Institute. It also provides living quarters for a limited number of men associated with the foregoing institutions, including specially economical sleeping quarters for about cighteen graduate students.

Description of the Undergraduate and Fifth-Year Courses

THE COURSES IN ENGINEERING

The five-year plan of engineering instruction is based on recognition of the fact that a four-year period of study is inadequate to give satisfactorily the combination of cultural, basic scientific, and engineering studies essential to the highest type of engineer, and to afford at the same time leisure for the development of the physical well-being and human interests of the students. The four-year Course trains, more broadly and fundamentally than the Engineering Courses now given at most institutions, the large proportion of students who study engineering not to make themselves engineering experts in a specialized sense, but to fit themselves to fill satisfactorily administrative positions in the utilities and manufacturing industries, and to serve as operating and constructing engineers in such industries. The fifth-year Courses, based on this broad fundamental preparation, and coordinated with it so as to constitute a harmonious, unified, fiveyear period of study, with no sharp breaks between the undergraduate and graduate periods, will afford the more intensive training required by the engineer who is to do creative work in his field.

The four-year Course in Engineering includes an unusually thorough training in physics and mathematics, and instruction in chemistry and geology; also extended courses, continuing throughout the four years, in humanistic studies, including English writing and speaking, literature, evolutionary science, history of civilization, current social and political problems, and economics; and, finally, those engineering subjects common to all branches of engineering, such as surveying, mechanism, descriptive geometry, machine drawing, applied mechanics, engineering materials, hydraulics, and preliminary courses in Civil, Mechanical, and Electrical Engineering. The fifth-year Courses in Civil, Mechanical, Electrical, and Aeronautical Engineering consist mainly of the engineering subjects that are fundamental in these separate branches of engineering. Thus the Civil Engineering Course deals largely with the analysis, design and construction of water systems, sanitation works and structures; the Mechanical Engineering Course, with machine design, steam and gas engineering, and powerplant design and operation; the Electrical Engineering Course with the generation, transmission and utilization of electric power and the communication of intelligence by electrical means; and the Aeronautical Engineering Course with the principles of aerodynamics, the design and construction of airplanes, their engines and instruments. Of all these Courses, engineering research or design forms an important part.

THE COURSES IN SCIENCE

The Courses in Science prepare for those scientific and engineering professions in which an intensive training in the basic sciences and in research is of more importance than a knowledge of the principles and practice of engineering. Accordingly, the four-year Course in Science, while including the same historical, literary and economic subjects as the Course in Engineering, requires much more extended study of the three sciences of chemistry, physics, and mathematics; also two years' study of scientific German and French. In its junior and senior years there are offered a series of Options which, when supplemented by the corresponding fifth-year Courses, afford definite preparation for various scientific professions, as outlined in the following statement.

The Option in Chemistry and the Option in Physics and the fifth-year Courses in Chemistry and Physics prepare students, on the chemical and physical sides respectively, for research and teaching in universities, colleges, and high schools, and for research positions in government laboratories and especially in the research and development departments of the larger chemical, metallurgical, and electrical companies.

The Option in Applied Chemistry and the fifth-year Courses in Chemical Engineering differ from those in Chemistry in that they include, in place of some of the science work, general subjects in mechanical and electrical engineering, and (in the fifth year) an extended treatment of chemical engineering itself. This Course is designed to fit men for the installation, operation, and the research development of industrial chemical processes.

The Geology Option and the Graduate Course in Geology and Paleontology prepare for teaching and research positions in colleges and universities, for government posts in connection with geological and mining surveys, for places as directors and field explorers of museums and, above all, for expert work in geology in the oil and mining industries.

The Biology Option and the Graduate Course in Biology prepare for teaching and research in colleges and universities, for government service in agriculture and public health, and for field studies and laboratory research in connection with museums. The Option of the Undergraduate Course affords a preliminary training, with emphasis on the fundamental sciences, for those who desire to pursue graduate studies in medicine, sanitation, and the public health.

Schedules of the Undergraduate Courses

The school year is divided into three terms. The number of units assigned in any term to any subject is the total number of hours per week devoted to that subject, including class work, laboratory work, and the estimated time for outside preparation. Laboratory assignments include drawing exercises and field work.

Besides the subjects shown in the course schedules, students take Assembly (1 unit) and Physical Education (3 units) in each term of each of the four school years. Students who continue their undergraduate work beyond four years continue to take Physical Education throughout their undergraduate course. Freshmen attend in the second and third terms, in addition to the general assemblies, six orientation assemblies.

The subject numbers correspond to those given in the Description of Subjects on pages 159-239. The abbreviations denote the various branches of instruction as follows:

Aeronautical Engineering	AE
Applied Chemistry	A Ch
Applied Mechanics	AM
Applied Physics	A Ph
Assembly	As
Astronomy	Ау
Biology	Bi
Chemistry	Ch
Civil Engineering	CE
Drawing	D
Economics	Ec
Electrical Engineering	EE
English	En
Geology	Ge
History and Government	H
Hydraulics	Hy
Languages	L
Mathematics	Ма
Mechanical Engineering	ME
Meteorology	Му
Philosophy	Pl
Physical Education	PE
Physics	Ph
Thesis	Th

SCHEDULES OF THE UNDERGRADUATE COURSES

BOTH COURSES

FIRST YEAR, ALL THREE TERMS

En 1 abc	English* (3-0-3)**	Jnits per 6	Term
Ph 1 abc	Physics* (3-3-6)	12	
Ch 1 abc	Chemistry* (3-6-3)	12	
Ma 1 abc	Mathematics* (4-0-8)	12	
H 1 abc	History (3-0-2)	5	
D 1, 3 ab	Drawing*** (0-3-0)	3	

*Students are required to pass, at the end of the Sophomore year, comprehensive examinations in English and History, in Physics, and in Mathematics. Students taking the Options in Chemistry or Applied Chemistry are required to pass also a comprehensive examination in Chemistry. **Number of hours devoted to class, laboratory, and preparation.

***D 1 is taken by all freshmen the first term, and D 3a, b, the second and third terms, respectively.

COURSE IN ENGINEERING

FOR STUDENTS PREPARING FOR CIVIL, MECHANICAL, ELECTRICAL, AND AERONAUTICAL ENGINEERING

	SECOND YEAR	Unit: 1st	s per 2nd	Term 3rd
Ma 2 abc	Mathematics*+ (4-0-8)**	12	12	8*
Ph 2 abc	Physics*† (3-3-6)	12	12	8*
Ma2d	Mathematics Review+ (4-0-8)			4*
Ph2d	Physics Review (3-3-6)			4*
H 2 abc	History*** (2-0-4)	6	6	6
CE 1	Surveying (3-4-4)		11 o	r 11
ME 1	Mechanism (3-3-3)	9 or	9 0	r 9
ME 3	Materials and Processes (3-3-5)		11 0	r 11
Ge 1a	Geology (3-3-3)	9		
D 3c	Descriptive Geometry (0-3-0)	3 or	3	
D 3d	Descriptive Geometry (0-3-0)		3 03	r 3
D 6a	Engineering Drawing (0-6-0)	6 or	6	.
D 6b	Engineering Drawing (0-6-0)		6 OI	r 6

*Students in the first honor section complete the regular work in Mathematics and in Physics during the first two terms and take in the third term Vector Analysis (Ma 14) and Modern Physics (Ph 3). Such students do not take Physics Review (Ph 2d) and Mathematics Review (Ma 2d).

iStudents not in the first honor section take in the first 7 weeks of the third term Physics Ph 2c (8 units) and Mathematics Ma 2c (8 units), and in the last three weeks Physics Review Ph 2d (4 units) and Mathematics Review Ma 2d (4 units). A condition in either of these review subjects, unless made up in September, excludes the student from all third-year subjects for which these are prerequisite. To assist students in making up such conditions, and to aid students transferring from other colleges who may not have had such intensive courses as those of the Institute, each of these subjects will be offered as a summer course (with a fee of \$20 each) during the three weeks preceding the opening of the fall term, provided not less than six students apply for it.

**Number of hours devoted to class, laboratory, and preparation.

***All students are required to pass a comprehensive examination in English and History at the end of the sophomore year.

COURSE IN ENGINEERING ELECTRICAL ENGINEERING OPTION

		(For First and Second Years, see pages 141 and 14	42)		
			Units	per	Term
		THIRD YEAR	lst	2nd	3rd
En	7 abc	English (3-0-5)	8	8	8
AM	[1 abc	Applied Mechanics (4-3-7)	14	14	14
Ge	la	Geology* (3-3-3)	9	.	
Ch	6	Engineering Chemistry (3-0-6)	9		•····
Ec :	17	Accounting (3-0-6)	9		
\mathbf{EE}	2	Direct Currents (3-0-6)		9	
EE	3	Direct Current Laboratory (0-3-3)		6	
\mathbf{EE}	4	Alternating Currents (3-0-6)			9
\mathbf{EE}	5	Alternating Current Laboratory (0-3-3)			6
A:	Ma 11	Differential Equations (3-0-6)	9	••••	•
	ME 15	Heat Engineering (3-3-6)	•	12	
	Hy 1	Hydraulics (3-3-6)	.		12
B:	Ph 5 ab	e Mathematical Physics (4-0-8)	12	12	12

FOURTH YEAR

	Humanities Electives** (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	
H 10	U. S. Constitution (1-0-1)		••••	2
Ec 2	Economics (4-0-6)		10	
Ec 25	Business Law (3-0-3)	6		••••
EE 6 ab	Electrical Machinery (2-0-4) (3-0-6)		6	9
EE 7	Electrical Engineering Laboratory (0-3-6)			9
EE 12	Electric Circuits (3-0-9)	12		
EE 70 abc	Engineering Conferences	2	\mathcal{D}	2
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	
A+: CE9	Structures (3-3-6)		12	
ME 27	Mechanical Laboratory (0-3-6)	9		
ME 18	Heat Engineering (3-0-7)			10
B+: EE 162	Vacuum Tubes (4-0-8)			12
ME 15	Heat Engineering (3-3-6)		12	
Hy 1	Hydraulics (3-3-6)	12		

*Beginning with 1936-37, Geology 1a will be offered in the sophomore year only.

**Humanities Electives

Pl1

Pl 4

Philosophy (Soares) Ethics (Soares) Contemporary Literature (Eagleson, Judy) American Literature (MacMinn) En 8

En 9

En 10 En 11 Modern Drama (Stanton, Huse)

Literature of the Bible (MacMinn) German Literature (Macarthur)

L 40 Pl 5

Plo German Literature (Macarthur) Pl5 Sociology (Laing) Students are required to take one term of Philosophy or Ethics, and choose two terms from the other electives. The assignment to each sub-ject is 9 units (3-0-6).

†Options A and B in the fourth year are dependent upon the third year options, except for third term, when ME 18 or EE 162 may be substituted by students in either group.

COURSE IN ENGINEERING CIVIL ENGINEERING OPTION

(For First and Second Years, see pages 141 and 142)

	THIRD YEAR	Units	per 2nd	Term 3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
CE 2	Advanced Surveying (3-6-3)	12		
Ge 1a	Geology* (3-3-3)	9		••••
Ch 6	Engineering Chemistry (3-0-6)	9		
Ec 25	Business Law (3-0-3)	6		
Hy 1	Hydraulics (3-3-6)	•	12	
Ec 17	Accounting (3-0-6)		9	
CE 4	Highway Engineering (3-0-3)	.	6	
ME 15	Heat Engineering (3-3-6)			12
Ec 2	Economics (4-0-6)			10
Hy 2	Hydraulics Laboratory (0-3-3)			6

FOURTH YEAR

	Humanities Electives ^{**} (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	$\boldsymbol{2}$	2	
H 10	U. S. Constitution (1-0-1)			2
CE 14 abc	Engineering Conferences	2	2	2
AM 3	Testing Materials (0-3-3)		6	
CE 8 abc	Railway Engineering	6	6	6
CE 10 abc	Theory of Structures	12	12	9
CE 12	Reinforced Concrete (3-3-6)			12
EE 8	Direct Currents (3-0-4)	7		
EE 9	Direct Current Laboratory (0-3-2)	5		•
Hy 3	Hydraulics Problems (0-6-0)	6		••••
EE 10	Alternating Currents (3-0-4)		7	
EE11	Alternating Currents Laboratory (0-3-2)		5	
Ge 10	Engineering Geology*** (2-2-5)		" سندر	9

*Beginning with 1936-37, Geology 1a will be offered in the sophomore **See second footnote on page 143. ***Men anticipating fifth year may elect Ma. 11 (9 units) as an alternate.

2
COURSE IN ENGINEERING MECHANICAL ENGINEERING OPTION

(For First and Second Years, see pages 141 and 142)

		THIRD YEAR	Units 1 st	per 2nd	Term 3rd	
	En 7 abc	English (3-0-5)	8	8	8	
	AM 1 abc	Applied Mechanics (4-3-7)	14	14	14	
L-	Hy 1	Hydraulics (3-3-6)	12			
	Ge 1a	Geology* (3-3-3)	9			
	Ch 6	Engineering Chemistry (3-0-6)	9			
	Ec 25	Business Law (3-0-3)	6			
4	ME 15	Heat Engineering (3-3-6)	•	12		
	Ec 2	Economics (4-0-6)		10		
L	Hy 2	Hydraulics Laboratory (0-3-3)		6		
	ME 16	Heat Engineering (4-0-8)	.		12	
	Ec 17	Accounting (3-0-6)			9	
~	ME 25	Mechanical Laboratory (0-3-3)	•		6	
		• • •				

FOURTH YEAR

	Humanities Electives ^{**} (3-0-6) 9	9	9
H 5 ab	Current Topics (1-0-1) 2	2	
H 10	U. S. Constitution (1-0-1)		2
ME 50	Engineering Conferences (1-0-1) 2	2	2
AM 3	Testing Materials (0-3-3)		6
CE 9	Structures (3-3-6)	12	
ME 5a	Machine Design (2-3-4) 9		
ME 5b	Machine Design (3-3-6)	12	
ME 5c	Machine Design (0-9-0)		9
ME 10	Metallurgy (2-0-4) 6		
ME 17	Heat Engineering (3-0-6) 9	•	
ME 26	Mechanical Laboratory (0-3-3)	. 6	
EE 8	Direct Currents (3-0-4) 7		
EE 9	Direct Currents Laboratory (0-3-2) 5		.
EE 10	Alternating Currents (3-0-4)		7
EE 11	Alternating Currents Laboratory (0-3-2)	. 50	or 5 🧹
	Elective	. 6	9

*Beginning with 1936-37, Geology 1a will be offered in the sophomore

year only. **See second footnote on page 143. †To be selected from Electives on page 146. Ma 11, Differential Equa-tions advised for all who expect to take fifth year.

COURSE IN ENGINEERING AERONAUTICS OPTION

	· · · · · · · · · · · · · · · · · · ·		
	(For First and Second Years, see pages 141 and 142)		
	THIRD YEAR U	nits per	Tern
D- Cabo	Exalish (9.0 t)	2nd	3r0
AMLaba	$\frac{\text{Elightsh}}{\text{Applied Mechanics}} \left(4.9.7\right) $	14	14
× Un 1	Hydraulics $(3, 3, 6)$ 10	1.45 1	14
Gole	$Goology * (2.2.3) \qquad \qquad$		
Che	Engineering Chemistry $(3-0-6)$		
Ec 25	Business Law (3-0-3) 6		•
ν ME 15	Heat Engineering (3-3-6)	12	
Ec 2	Economics (4-0-6)	· 10	••••
v Hv Q	Hydraulics Laboratory (0-3-3)	6	
Ec 17	Accounting (3-0-6)	•.	9
1 ME 25	Mechanical Laboratory (0-3-3)		6
Ma 11	Differential Equations (3-0-6)		g
1144 2 2			
	FOURTH YEAR	0	0
TT b 1	Humanities Electives ^{**} $(3-0-6)$	9	9
H 5 ab	$Urrent Topics (1-0-1) \dots 2$	2	••••
H 10 M. O. Jac	U. S. Constitution $(1-0-1)$		20
Masabe	Advanced Calculus (3-0-0)	9	9
Or Maltaba	Higher Mathematics for Engineers	0	0
Ma IS AUC	Direct Currents (2-0-4)	5	-0
EE 0	Direct Currents I shore tory $(0-3-2)$		
V MES	Machine Design (3-3-6)		
ME 10	Metallurov $(2-0-4)$		•
AM 3	Testing Materials Laboratory (0-3-3)	6	
AE 1	Aeronautics (3-0-6)	9	
AE 2 ab	Aircraft Structures	12	12
EE 10	Alternating Currents (3-0-4)		7
EE 11	Alternating Currents Laboratory (0-3-2)		5
	Elective	5	8
	DEDAGTOTELE ELECTIVES IN MUER ENTRET VEAD	- 3	1-1-1
M - 0 - 1 -	Advand Odval	10	10
Ma 8 abc	Advanced Calculus 12	12	12
Mo 11	Differential Fountiens 0	or 9	or 9
Ma 14	Vector Analysis	•	10
Bil 9	Biology	 0	0
Ge 1h	Paleontology	0	á
CE 12	Reinforced Concrete		12
ME 10	Metallurov 6	••••	12
ME 19	Heat Engineering	6	
Hv 4	Hydraulic Machinery		
Ec 18	Industrial Accounting	6	
Ec 20	Financial Organization		
	Special Problems or Research-(Units to be arra	nged)	
		~ /	

*Beginning with 1936-37, Geology 1a will be offered in the sophomore year only. **See second footnote on page 143.

V

COURSE IN SCIENCE

FOR STUDENTS PREPARING FOR CHEMISTRY, APPLIED CHEMISTRY, PHYSICS, INDUSTRIAL PHYSICS, MATHEMATICS, GEOLOGY, PALEONTOLOGY, BIOLOGY, ASTRONOMY AND MEDICINE

(For First Year, see page 141)

	SECOND YEAR	Units	per 2nd	Term 3rd	
Ma 2 abc	Mathematics*+ (4-0-8)	12	12	8*	
Ph 2 abc	Physics*+ (3-3-6)	12	12	8*	
Ma 2d	Mathematics Review (4-0-8)			4*	
Ph 2d	Physics Review (3-3-6)			4*	
H 2 abc	History (2-0-4)	6	6	6	
Ch 12 ab	Chemistry (2-6-2)	10	10		
Ge 1a	Geology (3-3-3)	9		•	
Bi 1	Biology (3-3-3)	••••	9		
Ge 1b	Paleontology (4-1-4) or				
Bi 2	Biology (3-4-2) or			9	
Ay 1	Astronomy (3-1-5)				
	Options as below	•		10	
	OPTIONS				
	CHEMISTRY AND APPLIED CHEMISTRY				
Ch 12c	Analytical Chem. and Chem. Review ^{**} (2-6-2)		••••	10	
	PHYSICS OR APPLIED PHYSICS				
Ch 43	Organic Chemistry (2-6-2)	••••		10	
	BIOLOGY				
Bi 4	Invertebrate Zoology	••••	••••	10	
	STAUTTERSTAUTCE OD DTIVETCO				
M. 9	Theory of Equations (2.0.7)			10	
ma 3	Theory of Equations (3-0-1)	•		10	
GEOLOGY ^{***}					
CE 1	Surveying (3-4-4)		•	11	
D 5	Descriptive Geometry (0-3-0)	•		3	
Ge 1c	Historical Geology (3-0-6)	••••		9	
-					

*Students in the first honor section complete the regular work in Mathematics and in Physics during the first two terms, and take in the third term Vector Analysis (Ma 14) and Modern Physics (Ph 3). Students in the first honor section do not take Mathematics Review (Ma 2d) and Physics Review (Ph 2d).

Physics Review (Ph 2d). istudents not in the first honor section take in the first 7 weeks of the third term Physics Ph 2c (8 units) and Mathematics Ma 2c (8 units), and in the last 3 weeks Physics Review Ph 2d (4 units) and Mathematics Review Ma 2d (4 units). A condition in either of these review subjects, unless made up in September, excludes the student from all third-year subjects for which these are prerequisite. To assist students in making up conditions, and to aid students transferring from other colleges who may not have had such intensive courses as those of the Institute, each of these subjects will be offered as a summer course (with a fee of \$20) during the 3 weeks preceding the opening of the fall term, provided not less than six students apply for it.

tess than six students apply for it.
**To be admitted to the options in Chemistry and Applied Chemistry in the third year students must satisfactorily pass the subject, Ch 12c.
***Students in Geology do not take Mathematics the third term.

147

COURSE IN SCIENCE

PHYSICS OR ASTRONOMY OPTION

(For First and Second Years, see pages 141 and 147)

	THIRD YEAR	Units	per	Term
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
$\begin{array}{c} Ch 21a \\ Ch 23 ab \end{array}$	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	<u>`</u> 9
H 5 ab	Current Topics (1-0-1)	2	2	••••
H 10	U. S. Constitution (1-0-1)			2
Ec 5 ab	Economics (3-0-3) and (2-0-4)		6	6
L 35a	German (4-0-6) 1	0		
L I ab	French (4-0-6)		10	10
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
Ma 12	Probability and Least Squares (2-0-4)	6		••

PHYSICS OPTION

Ph 101 abc	Electricity and Magnetism (3-0-6)	9	. 9	9
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

*See second footnote on page 143.,

COURSE IN SCIENCE APPLIED PHYSICS OPTION

(For First and Second Years, see pages 141 and 147)

	THIRD YEAR	Units	per	Term
En 7 abc	English (3-0-5)	8	211u 8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21a Ch 23 ab (Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	
H 10	U. S. Constitution (1-0-1)			2
Ec 5 ab	Economics (3-0-3 or 2-0-4)		6	6
L 35 abc	German (4-0-6 or 3-0-3)	10	10**	10**
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
EE 8, 9	Direct Currents (3-3-6)			
EE 10, 11	Alternating Currents (3-3-6)	12	12	12
ME 15	Heat Engineering (3-3-6)			

*See second footnote on page 143.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE

MATHEMATICS OPTION

(For First and Second Years, see pages 141 and 147)

	THIRD YEAR	Units	per	Term
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21a	Chemical Principles (4-0-6)	10		
Ma 4 ab	Analytic Geometry (3-0-7)		10	10
Ma 8 abc	Advanced Calculus (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	
H 10	U. S. Constitution (1-0-1)			2
Ec 5 ab	Economics $(3-0-3 \text{ or } 2-0-4)$		6	6
L 35a	German (4-0-6)	10		
L 1 ab	French (4-0-6)		10	10
Ma 106 abc	Introduction to Theory of Functions of Real			
	Variables	5	5	5
Ma 107	Conformal Representation		9	
Ma 101 abc	Modern Algebra (3 lectures a week)	6	6	6
Ma 102 ab	Higher Geometry (3-0-6)**	9	9	
Ma 201 a	Modern Analysis	15		

*See second footnote on page 143. **See note, page 169.

COURSE IN SCIENCE CHEMISTRY OPTION

(For First and Second Years, see pages 141 and 147)

	THIRD YEAR	Units	per	Term
		1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 abc	Chemical Principles (4-0-6)	10	10	10
Ch 26 ab	Physico-Chemical Laboratory (0-6-2 or 0-3-1)		8	4
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 ab	Organic Chemistry Laboratory (0-12-0; 0-6-0)	12	6	
Ch 13 a	Inorganic Chemistry (2-0-2)			4
Ch 14 a	Inorganic Chemistry Lab. (0-8-0)			8

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
5 ab	Current Topics (1-0-1)	2	2	
10	U. S. Constitution (1-0-1)		.	2
2	Economics (4-0-6)		10	
5 abc	German (4-0-6 or 3-0-3)	10	6^*	* 6**
22 ab	Thermodynamic Chemistry (2-0-4)	6	6	
61 ab c	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
16	Instrumental Analysis (0-6-2)	8		
70-73	Chemical Research (0-5-0 or 0-19-0)		5	19
29	Colloid and Surface Chemistry (3-0-5)			8
Ch 13 b	Inorganic Chemistry (2-0-2)	4		
Ch 14 bc	Inorganic Chemistry Lab. (0-5-0 or 0-8-0)	5	8	
Ph 5 ab	Introduction to Math. Physics (4-0-8)	12	12	
	5 ab 10 2 5 abc 22 ab 61 abc 16 70-73 29 Ch 13 b Ch 13 b Ch 14 bc Ph 5 ab	Humanities Electives* (3-0-6) 5 ab Current Topics (1-0-1) 10 U. S. Constitution (1-0-1) 2 Economics (4-0-6) 5 abc German (4-0-6 or 3-0-3) 22 ab Thermodynamic Chemistry (2-0-4) 61 abc Industrial Chemistry (2-0-4 or 2-0-2) 16 Instrumental Analysis (0-6-2) 70-73 Chemical Research (0-5-0 or 0-19-0) 29 Colloid and Surface Chemistry (2-0-2) Ch 13 b Inorganic Chemistry (2-0-2) Ch 14 bc Inorganic Chemistry Lab. (0-5-0 or 0-8-0) Ph 5 ab Introduction to Math. Physics (4-0-8)	Humanities Electives* (3-0-6) 9 5 ab Current Topics (1-0-1) 2 10 U. S. Constitution (1-0-1) 2 2 Economics (4-0-6)	Humanities Electives* (3-0-6)

*See first footnote on page 143.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE

APPLIED CHEMISTRY OPTION

(For First and Second Years, see pages 141 and 147)

	THIRD YEAR	Units	per	Term
D. C. ba	$E_{\rm reliab}$ (9.0 t)	1st	2nd	3rd
En 7 abc	English $(3-0-3)$	ð	•	0
L 32 abc	German (4-0-6)	10	10	10
Ch 21 abc	Chemical Principles (4-0-6)	10	10	10
AM 2 ab	Applied Mechanics (4-0-8)	12	12	
Ch 63 ab	Chem. Eng. Thermodynamics (2-0-4)		6	6
Ec 2	Economics (4-0-6)	••••		10
Ch 26 ab	Physical Chemistry Laboratory (0-3-1)		4	4
Ch 16	Instrumental Analysis (0-6-2)	8		

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	
H 10	U. S. Constitution (1-0-1)			2
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 ab	Organic Chemistry Laboratory (0-9-0)	9	9	
Ch 29	Colloid and Surface Chemistry (3-0-5)			8
Ch 22a	Thermodynamic Chemistry (2-0-4)	6		
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
EE 8, 9	Direct Currents (3-3-6)		12	
EE 10, 11	Alternating Currents (3-3-6)			12

*See second footnote on page 143.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE

GEOLOGICAL SCIENCES OPTION*

(For First and Second Years, see pages 141 and 147)

	THIRD YEAR	Units 1st	per 2nd	Term 3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21a Ch 23a	Chemical Principles (4-0-6)	10	10	
CE 3	Plane Table Surveying (1-6-1)			8
Ge 3 abc	Mineralogy	12	12	12
Ge 14	Geologic Illustration	10		
Ge 7 ab	Field Geology		10	10

FOURTH YEAR

	Humanities Electives** (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	
H 10	U. S. Constitution (1-0-1)			2
Ec 5 ab	Economics (3-0-3 or 2-0-4)		6	6
L 35 abc	German (4-0-6 or 3-0-3)	10	6***	6***
Ge 9	Structural Geology (4-0-6)	10	•	
Ge 11 ab	Invertebrate Paleontology#	8	10	
Ge 12 ab	Vertebrate Paleontology (2-6-2)#	•	10	10
Ge 5	Optical Mineralogy $(2-6-2)$ #	10		
Ge 6 ab	Petrography#		10	14
Ge 100	Geology-Paleontology Club	1	1	1
Ge 21, 22	Thesis#			·

*Summer Field Geology required after both Junior and Senior Years. **See second footnote on page 143.

***Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

#Students desiring to specialize in physical geology may take Ge 5 and Ge 6 in conjunction with one paleontology course. Those desiring to specialize in paleontology may take both Ge 11 and Ge 12, omitting Ge 5 and Ge 6. In either case the course not taken in the fourth year will be taken in the fifth. Thesis units, Ge 21 or 22, arranged to bring total units per term to 50.

CALIFORNIA INSTITUTE OF TECHNOLOGY

COURSE IN SCIENCE

BIOLOGY OPTION

(For First and Second Years, see pages 141 and 147)

	THIRD YEAR*	Units	per	Term
En 7 abc	English (3-0-5)	1st 8	2nd 8	8
L 32 abc	German (4-0-6)	10	10	10
$\operatorname{Ec} 2$	Economics (4-0-6)	.	10	
Ch 41 ac	Organic Chemistry (3-0-5, 2-0-4)	8		6
Bi 13	Mammalian Anatomy (1-2-2)	5		
Bi 12	Histology (1-6-2)	9		
Bi 16	Animal Physiology (3-2-5)	10	10	
Bi 6	Embryology $(2-8-2)$	 '	12	
Bi S	Advanced Genetics (3-5-4)			12
Bi 3	Botany (2-9-3)			14

FOURTH YEAR

	Humanities Electives ^{**} (3-0-6)	9	9
H 5 ab	Current Topics (1-0-1) 2	\mathcal{D}	
H 10	U. S. Constitution (1-0-1)		\mathcal{Q}
L 35a	German (4-0-6) 10		
L1ab	French (4-0-6)	10	10
Ch 21a Ch 23 ab	Chemical Principles (4-0-6) 10	10	10
Ch 26	Physical Chemistry Laboratory (0-3-1)		4
Bi 7 ab	Biochemistry $(2-4-4)$ 10	10	
Bi 5 ab	Plant Physiology (2-6-2) 10	10	
	And one of the following:		
Bi 10	Bacteriology		
Bi 11	Entomology		14
Bi 15	Cytology		1.4
Bi 22	Research		

*Students taking the Biology Option are urged to take Bi 17 (Vertebrate Anatomy, 10 units), at Corona del Mar in the summer between their sec-ond and third years. **See footnote on page 143.

Schedules of Courses for the Degree of Master of Science

	SUBJECTS COMMON TO ALL COURSES Unit	s per	Term	
H 100 En 100 Pl 100	Seminar in American History and Government or English Literature	9	9	
Ec 100 abc	\rightarrow or Business Economics	12	12	
	Engineering or Research Seminars	\mathcal{D}	2	
	Professional Subjects	42	42	
	ELECTRICAL ENGINEERING		,	
	Subjects common to all courses	11	11	
EE 120	Alternating Current Analysis 12			
EE 122	Advanced Alternating Current Machinery	12		
EE 144	Transmission Lines		12	
EE 121 abc	Alternating Current Laboratory	6	6	
EE 148	Specifications and Design 0			
EE 160 EE 159	Dielectrice Transfelits	U	6	
EE 102	Research or Thesis	12	12	
	Electives, as below	6	6	
	FT ROWINDO			
EE 162	Vacuum Tubes		10	
EE 128	Electric Traction	6	12	
${ m EE}156$	Electrical Communication		••••	
EE 130	Light and Power Distribution		6	
	CIVIL ENGINEERING			
	Subjects common to all courses 11	11	11	
CE 23	Statically Indeterminate Structures 15		-75	
CE 16	Masonry Structures			
Ma 15 abc	Higher Mathematics for Engineers	12	9	
CE 13 °	Structural and Civil Engineering Design 19	12		
CE 17	Sewerage	3	9	
AM 105	Soil Mechanics	6	·9	
	Research or Other Thesis 6-	86	6	
5-	SUPPLEMENTARY SUBJECTS			
CE 101 ab	Water Power Plant Design 10	01		
CE 105 bc	Statically Indeterminate Structures			
CE 107 abc	Geodesy and Precise Surveying	6	6	
CE 108	Highway Problems	•		
CE 110 bc	Sewage Treatment Plant Design	10	10	
CE 114	Earthquake Effects upon Structures	••••	•	
Ge 10	Engineering Geology	···	9	
AE 270 AE 279 aba	Sympositic Moteorology 12	0 10	10	
Ph 5 ah	Introduction to Mathematical Physics 12	12	12	

61 - 2

	MECHANICAL ENGINEERING	Units	per 2nd	Term
	Subjects common to all courses (page 155)	11	11	11
ME 110a	Science of Metals	6		
ME 111a	Metallography Laboratory	6	•	
ME 120	Heat Engineering	12		
Ma 15	Higher Mathematics for Engineers			
	or	9	9	9
Ma 8	Advanced Calculus			
	Electives, as below	9*	33	33
	ELECTIVES			
ME 101 ab	Advanced Machine Design		12	12
ME 110 bc	Science of Metals		6	6
ME 111 bc	Metallography Laboratory		6	6
ME 121, 122	Heat Engineering		12	12
Hy 100	Applied Hydrodynamics		12	
Hy 101	Hydraulic Machinery		••••	12
•	Research or Thesis, as arranged	•		

*Ma 11 Differential Equations must be taken in the first term unless the student has already passed the course in the fourth year.

PHYSICS OR APPLIED PHYSICS

Subject	ts common	to	all	courses	(page	155))	11	11	11
---------	-----------	----	-----	---------	-------	------	---	----	----	----

ELECTIVES

Ph 110 ab	Kinetic Theory		12	12
Ph 107 abc	Atomic Physics	9	9	9
Ph 108	Spectroscopy Laboratory		3	
Ph 103 abc	Analytical Mechanics	12	12	12
Ph 105 ab	Optics	9	9	
Ph 106 ab	Optics Laboratory	3	3	
EE 162	Vacuum Tubes			12
Ma 109 abc	Mathematical Analysis	9	9	9
or	v			
Ma. 114	Mathematical Analysis	12	12	12
Ph 114	Principles of Quantum Mechanics			9
Ph 115	Applications of Quantum Mechanics	9		
	Research	15	15	15

MATHEMATICS

Subjects common to all courses (page 155) 1	11	11	11
Courses open to graduates in Mathematics Curricu Research Subjects in fifth-year Physics Course	lum 6	6	6

CHEMISTRY OR CHEMICAL ENGINEERING

	Units	per	i ermi
	1st	2nd	3rd
Subjects common to all courses (page 155) 11	11	11
	<i>,</i>		

-

ELECTIVES

Ch 153	Thermodynamic Chemistry	6	6	
Ch 155 abc	Nature of Chemical Bond	6	6	6
Ch 156 abc	Introduction to Wave Mechanics	9	9	9
Ch 157 abc	Structure of Crystals	6	6	6
Ch158	Photochemistry	6		
Ch 159a	Kinetics of Homogeneous Reactions	6		
Ch 159b	Kinetics of Heterogeneous Reactions		6	•
Ch 161	Organic Chemical Analysis			9
Ch162 abc	Organic Chemistry (special topics)	6	6	6
Ch 166 abc	Chemical Engineering [*]	12	12	12
Ch 167	Phase Equilibria in Applied Chemistry		6	
Ch 169	Research Manipulations	3		
ME 25	Mechanical Laboratory	6	or 6 o	r 6
	Research	18	12-18 12	2-18

GEOLOGICAL SCIENCES

	Subjects common to all courses (page 155) 11	11	11
Ge 5	Optical Mineralogy** 10		
Ge 6 ab	Petrography**	10	14
Ge 8	Spring Field Trip		1
Ge 11 ab	Invertebrate Paleontology**	10	
Ge 12 ab	Vertebrate Paleontology**	10	10
Ge 100	Geology-Paleontology Club 1	1	1
Ge 195	Ore Deposits	10	
Ge 196	Non-Metalliferous Deposits		10
Ge 186	Geomorphology [†] 10		
Ge 183	Seismology‡	6	

ELECTIVES AS FOLLOWS

Ge 200 ab	Mineragraphy	9	9	••••
Ge 205, 206†	Applied Geophysics	5	5	
Ge 203	Introduction to General Geophysics	6		
Ge 189a	Structural Geology (Seminar)	5		
Ge 189b	Physical Geology (Seminar)			5
Ge 191 ab	Invertebrate Paleontology (Seminar)	5	5	
Ge 190 ab	Vertebrate Paleontology (Seminar)		5	5
Ge 199	Mineralogy (Seminar)	5		

*Candidates for the Master's degree in Chemical Engineering are re-quired to take the subject Chemical Engineering. They must also have taken or take in this year the engineering subjects included in the Applied Chemistry Option of the Four-Year Course in Science. Their research must be in the fields of Applied Chemistry or Chemical Engineering. *The starred course not completed during the senior year is to be taken.

†1935-1936. ‡1936-1937.

CALIFORNIA INSTITUTE OF TECHNOLOGY

		Units 1st	per 2nd	Term 3rd
Ge 210	Advanced Petrology		8	
Ge 211	Petrology (Seminar)			5
Ge 10	Engineering Geology			9
Ge 197	Advanced Economic Geology		5	5
Ge 208 ab	Geophysics (Seminar)	5	.	5
Ge 220	History of Geology		5	
Ge 225	Geology of the Southwest ⁺	10		
Ge 188	Advanced Study		****	
Ge 187	Research			

AERONAUTICAL ENGINEERING

FIFTH YEAR

	Subjects common to all courses (page 155)	11	11	11
AE 251 abc	Aerodynamics of the Airplane	9	9	9
AE 252 abc	Airplane Design	12	12	12
AE 253 abc	Airplane Design and Testing Procedure	6	6	6
Ma 109 ab	Mathematical Analysis	9	9	
or				
EE 226	Engineering Math. Physics	15	15	••••
Ma 14	Vector Analysis			12
AE 290	Aeronautics Seminar	2	2	2
	Research and Electives			

SIXTH YEAR

AE 254 abc	Advanced Problems in Airplane Design	9	9	9
AE 266 ab	Theoretical Aerodynamics 1	12	9	
AE 267	Theoretical Aerodynamics II			12
AE 270	Elasticity Applied to Aeronautics	12	6	6
AE 290	Aeronautics Seminar	\mathcal{D}	2	2
	Research and Electives			

METEOROLOGY

FIFTH YEAR

	Subjects common to all courses (page 155)	11	11	11
AE 272 abc	Dynamic Meteorology	9	9	9
AE 273 abc	Synoptic Meteorology	12	12	12
AE 274 abc	Meteorological Laboratory	15	15	15
$\operatorname{AE}275$	Structure of the Atmosphere	.		3
AE 276	Meteorological Instruments	6		
AE 280	Research			
AE 290 abc	Aeronautics Seminar	\mathcal{D}	2	2
AE 291 abc	Meteorological Seminar	$\boldsymbol{2}$	2	2
	Ŷ.			

1

†1935-1936. ‡1936-1937.

Subjects of Instruction

DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

PHYSICS

PROFESSORS: HARRY BATEMAN, IRA S. BOWEN, PAUL S. EPSTEIN, WILLIAM V. HOUSTON, CHARLES C. LAURITSEN, ROBERT A. MILLIKAN, RICHARD C. TOLMAN, EARNEST C. WATSON

Associate Professors: Alexander Goetz, S. Stuart Mackeown, J. Robert Oppenheimer, Gennady W. Potapenko, William R. Smythe, Fritz Zwicky

Assistant Professor: Carl D. Anderson

INSTRUCTOR: H. VICTOR NEHER

SENIOR FELLOW IN RESEARCH: JOHN D. STRONG

UNDERGRADUATE SUBJECTS

Ph. 1 a, b, c. MECHANICS, MOLECULAR PHYSICS, AND HEAT. 12 units (3-3-6); first, second and third terms.

Prerequisites: A high school course, or its equivalent, and trigonometry.

The first year of a general college course in physics extending through two years. It is a thorough analytical course, in which the laboratory carries the thread of the work, and the problem method is largely used. A bi-weekly demonstration lecture, participated in by all members of the department, adds the inspirational and informational element, and serves for the development of breadth of view.

Text: Principles of Physics, Millikan, Roller and Watson.

Instructors: Watson, Lauritsen, Strong and Teaching Fellows.

Ph. 2 a, b, c. ELECTRICITY, SOUND, AND LIGHT. 12 units (3-3-6), first and second terms; 8 units, third term.

Prerequisites: A high school course, or its equivalent, and trigonometry.

Continuation of Ph. 1 a, b, c, to form a well-rounded two-year course in general physics.

Text: Electricity, Sound, and Light, Millikan and Mills.

Instructors: Anderson, Neher and Teaching Fellows.

Ph. 2 d. PHYSICS REVIEW. 4 units; last three weeks of sophomore year.

The last three weeks of the sophomore year are devoted to a comprehensive review and examination covering the whole of the two years' work (Ph. 1 a, b, c, and 2 a, b, c).

Ph. 3. MODERN PHYSICS. 12 units (2-6-4); third term.

Prerequisites: Ph. 1 a, b, c, 2 a, b; Ma. 2 a, b.

A brief survey of recent developments in electron theory, quantum theory, radioactivity, and atomic structure. Experiments to determine e, e/m, h, and other fundamental constants will be performed. Open only to students on honor standing, sophomore year.

Instructor: Anderson.

Ph. 5 a, b, c. INTRODUCTION TO MATHEMATICAL PHYSICS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

An introduction to the application of mathematics to physics, and practice in the solution of problems.

Instructor: Houston.

Ph. 7 a, b, c. ELECTRICITY AND MAGNETISM. 6 units (2-0-4); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A course in theoretical electricity and magnetism, primarily for electrical engineering students. Ph. 9 a, b (Electrical Measurements) must accompany this course.

Text: Principles of Electricity, Page and Adams.

Instructor: Mackeown.

Ph. 9 a, b, c. ELECTRICAL MEASUREMENTS. 4 units (0-3-1); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A laboratory course in advanced electrical measurements.

Text: Advanced Electrical Measurements, Smythe and Michels.

Instructors: Smythe and Assistants.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ph. 101 a, b, c. Electricity and Magnetism. 9 units (3-0-6); first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

A problem course in the mathematical theory of electricity and magnetism, intended primarily as a preparation for graduate work in science. Ph. 9 a, b, c (Electrical Measurements) should accompany or precede this course.

Text: Electricity and Magnetism, Jeans. Instructor: Smythe.

Ph. 103 a, b, c. ANALYTICAL MECHANICS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

A study of the fundamental principles of theoretical mechanics; force and the laws of motion; statics of systems of particles; the principle of virtual work, potential energy, stable and unstable equilibrium; motion of particles, systems of particles and rigid bodies; generalized coordinates, Hamilton's principle and the principle of least action; elementary hydrodynamics and elasticity.

Text: Dynamics, Webster. Instructor: Zwicky.

Ph. 105 a, b. Offics. 9 units (3-0-6); first and second terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

A problem course dealing with the fundamental principles of geometrical optics, of diffraction, interference, the electromagnetic theory of light, etc., and their experimental verification. Ph. 106 a, b (Optics Laboratory), should accompany this course.

Text: Theory of Optics, Drude. Instructor: Bowen.

Ph. 106 a, b. Optics Laboratory. 3 units (0-3-0); first and second terms.

Advanced laboratory work in light, consisting of accurate measurements in diffraction, dispersion, interference, polarization, spectrophotometry.

Text: Manual of Advanced Optics, Taylor. Instructor: Bowen.

Ph. 107 a, b, c. Atomic Physics. 9 units; first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

An outline of the experimental and theoretical basis of modern atomic physics, which covers electron theory, spectroscopy and nuclear physics.

Instructors: Millikan, Bowen, Anderson.

Ph. 108. SPECTROSCOPY LABORATORY. 3 units; second term.

A laboratory course in the measurement and classification of spectral lines to accompany Ph. 107 b.

Instructor: Bowen.

Ph. 110 a, b. KINETIC THEORY OF MATTER. 12 units; second and third terms.

Prerequisite: Ph. 1 a, b, c, d; Ma. 2 a, b, c, d.

Presents the modern aspects of the kinetic theory of gases, liquids and solids largely from the experimental point of view, covering in gases the Clausius equations, Maxwell distribution law, viscosities, specific heats, mean free paths, molecular magnitudes, high vacuum phenomena, etc.; in liquids, critical states, Brownian movements, diffusion, osmotic pressure; in solids, the interpretation of specific heats. Some thermionic and photoelectric problems will also be treated, and an occasional demonstration lecture will be given.

Instructor: Goetz.

Ph. 114. PRINCIPLES OF QUANTUM MECHANICS. 9 units; third term. Prerequisites: Ph. 5 a, b, c.; Ma. 8 a, b, c, or 10 a, b, c.

An outline, developed by means of problems, of the experimental and theoretical basis of quantum mechanics, including the idea of states, principle of indetermination, the Schroedinger equation, methods of approximate solution, electron spin, and Pauli principle.

Instructor: Houston.

Ph. 115. APPLICATIONS OF QUANTUM MECHANICS. 9 units; first term. Prerequisite: Ph. 114.

The application of non-relativistic quantum mechanics to problems in various fields of physics. The subjects treated will be determined partly by the interests of the class.

Instructor: Houston.

Ph. 142. RESEARCH IN PHYSICS. Units in accordance with the work accomplished.

GRADUATE SUBJECTS

Ph. 211. THERMODYNAMICS. 12 units; first term.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

The two fundamental laws of thermodynamics. Entropy and the thermodynamical potentials. Equations of reciprocity. Application to gases, perfect and imperfect, and to dilute solutions. Phase rule and chemical equilibrium. Nernst's theorem.

Instructor: Epstein.

.

Ph. 221. POTENTIAL THEORY. 15 units; third term.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

An exposition of the properties of the potential functions occurring in the theories of gravitation, electricity and magnetism, hydrodynamics, conduction of heat, and the theory of elasticity. Solution of special problems.

Instructor: Bateman.

Ph. 222. THEORY OF ELECTRICITY AND MAGNETISM. 12 units; first term.

Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

Electrostatics, magnetostatics, ferromagnetism, electromagnetic field of stationary currents, electromagnetic induction, phenomena in moving bodies, Maxwell's equations, ponderomotive forces of an electromagnetic field, introduction to the theory of electrons.

(Not given in 1935-1936.) Instructor: Epstein.

Ph. 223. THEORY OF ELECTROMAGNETIC WAVES. 12 units; second term. Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

Mathematical study of Maxwell's equations, propagation of waves, absorption and reflection, approximate and rigorous treatment of diffraction, theory of dispersion, electro- and magneto-optics.

(Not given in 1935-1936.) Instructor: Epstein.

Ph. 224. THEORY OF SOUND. 9 units; second term.

Prerequisites: Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

Vibrations of strings, rods, plates and of the larynx. Resonators, horns and musical instruments. Theories of hearing. The acoustics of an auditorium. The propagation of sound. Reflection, refraction and absorption of sound.

Instructor: Bateman.

Ph. 225. THEORY OF ELECTRONS. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 222; Ma. 8 a, b, c, 10 a, b, c.

Retarded potentials. Radiation of a point charge. Theory of dielectrics. Electron theory of dia-, para- and ferro-magnetism. Phenomena in moving bodies and experimental foundations of the theory of relativity.

(Not given in 1935-1936.) Instructor: Epstein. Ph. 226. HEAT RADIATION AND QUANTUM THEORY. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 211; Ma. 8 a, b, c, 10 a, b, c. Historical treatment of the development of the mathematical theory of heat radiation and of the application of the theory of quanta to the phenomena of specific heats of solid and gaseous bodies, photoelectricity, photochemistry, chemical constants, etc.

Instructor: Epstein.

Ph. 228. Modern Aspects of the QUANTUM THEORY. 12 units; third term.

Prerequisites: Ph. 103 a, b, c, 107 a, b, c, 229; Ma. 8 a, b, c, 10 a, b, c.

The course is devoted to a review of recent developments in the quantum theory, especially in the fields of the theory of radiation and of the electron theory of metals. The subject matter varies from year to year.

Instructor: Epstein.

Ph. 232. PHYSICS OF ULTRA-SHORT ELECTROMAGNETIC WAVES. 6 units (2-0-4); second and third terms.

Propagation of waves. Maxwell's dispersion and absorption in semiconductors and metals. Electronic and dipolar dispersion and absorption in dielectrics. Dispersion and absorption in electrolytes. Waves along wires and dispersion in magnetic substances.

Experimental results on dispersion and absorption of ultra-short waves in dielectrics, electrolytes and magnetic substances.

Instructor: Potapenko.

Ph. 234. TOPICS IN THEORETICAL PHYSICS. 9 units (3-0-6); third term.

The subject of this course will vary from year to year. Typical topics: Theory of atomic collisions; relativistic quantum theory; theory of radiation; statistical mechanics. In 1936 the course will deal with recent contributions to the theory of atomic nuclei; the problem of nuclear stability; nuclear collisions and transmutations; the interaction of neutrons with nuclei; nuclear radiative processes; and the phenomenological theory of beta-ray decay.

Instructor: Oppenheimer.

Ph. 236 a, b, c. INTRODUCTION TO THE THEORY OF RELATIVITY. 6 units; first, second and third terms.

The special theory of the relativity of motion in free space, with applications to mechanical and electromagnetic problems. Use of four dimensional language for expressing the results of relativity. Introduction to tensor analysis. The general theory of relativity and the theory of gravitation. Applications to thermodynamics and cosmology.

Text: Relativity, Thermodynamics and Cosmology, Richard C. Tolman.

(Not given in 1935-1936.) Instructor: Tolman.

Ph. 237. ASTROPHYSICS. 6 units (2-0-4); first and second terms. Prerequisites: The fundamental courses in physics.

Mechanics and thermodynamics of stellar bodies, constitution of stars, stellar atmospheres and their spectra, evolution of the planetary system and of stellar systems, time scales, characteristics of extragalactic nebulæ and their apparent velocities of recession, evolution of the universe, etc.

(Not given in 1935-1936.)

Instructor: Zwicky.

Ph. 238. SEMINAR ON THEORETICAL PHYSICS. 4 units; first, second and third terms.

Recent developments in theoretical physics for specialists in mathematical physics.

Instructor: Epstein.

Ph. 239. RESEARCH CONFERENCE ON THE PHYSICS OF Solids. 2 units; three terms.

This seminar is for graduate students interested in the field of the solid state and low temperature research.

Instructor: Goetz.

Ph. 240. SEMINAR ON X-RADIATION. 4 units; first, second, and third terms.

Meets once a week for reports and discussions of problems in X-Radiations. Standard texts on X-rays are followed in the first term as an outline only; the reports being amplifications and additions to the material of the text as drawn from the original papers of workers in the field. During the second and third terms advanced reports are made on current problems and on fundamental classical work.

Instructors: DuMond and Kirkpatrick.

Ph. 241. Research Conferences in Physics. 4 units; first, second and third terms.

Meets twice a week for report and discussion of the work appearing in the literature and that in progress in the laboratory. Advanced students in physics and members of the physics staff take part.

Instructors: Millikan, Bateman, Epstein, Tolman, Watson.

Ph. 242. RESEARCH IN PHYSICS. Units in accordance with the work accomplished.

Ph. 243 a, b, c. SEMINAR ON RADIATION AND NUCLEAR PHYSICS. 4 units; first, second and third terms.

Meets once each week and is intended primarily for the men working in the radiation laboratory. The problems in progress in the radiation laboratory are discussed and current literature relating to these problems are presented.

Text: Radiation from Radioactive Substances, Rutherford, Chadwick and Ellis.

Instructor: Lauritsen.

Ph. 244. SEMINAR ON METALS. 2 units; three terms. Designed for graduate students in engineering and science. Questions on the border of physics, chemistry, and metallurgy are discussed.

Instructors: Goetz, Clapp, von Karman.

ASTRONOMY AND PHYSICS CLUB.

The club, consisting of physicists and astronomers of the Institute and of the Mount Wilson Observatory, meets on the first Friday in each month either at the Institute or the Observatory Laboratory for the discussion of researches carried on by its members as well as those appearing in the journals.

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, HARRY C. VAN BUSKIRK Research Associate: Dinsmore Alter. Statistics

Associate Professors: Aristotle D. Michal, Morgan Ward, Luther E. Wear

Assistant Professor: William N. Birchby

UNDERGRADUATE SUBJECTS

Note: Students intending to take the mathematics option must indicate their choice by the end of the second term of their sophomore year.

Ma. 1 a, b, c. FRESHMAN MATHEMATICS. 12 units (4-0-8); first, second and third terms.

Including the fundamentals of analytical geometry, certain topics in college algebra, and some of the principles of the differential and integral calculus.

Texts: Elementary Calculus, Revised Edition, Woods and Bailey; Analytical Geometry, Revised Edition, Harding and Mullins.

Ma. 2 a, b, c. SOPHOMORE MATHEMATICS. 12 units (4-0-8); first and second terms; 8 units third term.

Prerequisite: Ma. 1 a, b, c.

Includes additional topics in analytical geometry, and completes the usual subjects of the calculus, begun in the freshman year.

Texts: Analytical Geometry, Revised Edition, Harding and Mullins; Elementary Calculus, Revised Edition, Woods and Bailey; Differential Equations, 3rd Edition, Phillips.

Ma. 2 d. MATHEMATICS REVIEW. 4 units (4-0-8).

A comprehensive review of freshman and sophomore mathematics during the last three weeks of the sophomore year.

Courses Ma. 1 a, b, c, and 2 a, b, c, d, form a continuous two-year course in analytical geometry, college algebra, and the differential and integral calculus.

Ma. 3. THEORY OF EQUATIONS. 10 units (3-0-7); third term.

Includes the elementary theorems in the roots of an equation, solution of numerical equations, determinants, symmetric functions, resultants and discriminants.

Instructor: Wear.

Ma. 4 a, b. ANALYTIC GEOMETRY. 10 units (3-0-7); second and third terms.

Prerequisites: Ma. 1 and 2.

Aims to acquaint the student majoring in mathematics with the basic ideas and methods of Higher Geometry. Subjects treated include: Homogeneous coordinates, line coordinates, cross-ratio, projective coordinates, point curves and line curves, projective and metric properties of conics, correlations.

Text: Graustein, Higher Geometry.

Instructor: Wear.

Ma. 8 a, b, c. ADVANCED CALCULUS. 9 or 12 units (3-0-6 or 4-0-8); first, second and third terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d.

Planned to extend the knowledge gained from the previous studies in calculus and analytic geometry and to lay a better foundation for advanced work in mathematics and science.

Text: Advanced Calculus, Woods.

Instructor: Birchby.

Ma. 10 a, b, c. DIFFERENTIAL EQUATIONS. 9 units (3-0-6); first, second and third terms.

Prerequisite: Ma. 2 a, b, c, d.

An introductory course in differential equations, designed to be helpful both to the student of mathematics and the student of science or engineering.

Text: Differential Equations, Ford.

Instructors: Wear, Taylor.

Ma. 11. DIFFERENTIAL EQUATIONS. 9 units (3-0-6); first or third terms.

Prerequisite: Ma. 2 a, b, c, d.

An abridged course in Differential Equations for students in Electrical Engineering.

Text: Differential Equations, 3rd Edition, Phillips.

Instructors: Van Buskirk, Elconin.

Ma. 12. PROBABILITY AND LEAST SQUARES. 6 units (2-0-4); first term. Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d.

A study of the fundamental principles of probability and their application to statistical data, adjustment of observations, and precision of measurements.

Text: Theory of Errors and Least Squares, Bartlett.

Ma. 14. VECTOB ANALYSIS. 12 units (4-0-8); third term. Prerequisites: Ma. 2 a, b, c, d.

Elementary vector operations (addition, multiplication) and their application to problems of geometry and physics are treated.

Instructors: Van Buskirk, Bollay.

Ma. 15 a, b, c. Higher Mathematics for Engineers and Physicists. 9 units; first, second, and third terms.

Prerequisites: Ma. 1, Ma. 2.

An alternative course to Ma. 8, Advanced Calculus, covering about the same range of subjects. Intended primarily for Engineers and Applied Physicists who do not expect to use advanced theory.

Text: Sokolnikoff, Higher Mathematics for Engineers and Physicists. Instructors: Birchby, Pipes.

UNDERGRADUATE OR GRADUATE SUBJECTS

Note: Those of the following courses for which there is a demand will be given periodically.

Ma. 101 a, b, c. MODERN ALGEBRA. 6 or 9 units; first, second and third terms.

Prerequisite: Ma. 8, reading knowledge of German. Instructor: Bell.

1

instructor. Dell.

Ma. 102 a, b, c. INTRODUCTION TO HIGHER GEOMETRY. 9 units; first, second and third terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d, 4 a, b.

A course in the modern methods of analytic geometry.

Nore: If all three terms are not included in the undergraduate course, graduate students in mathematics must complete this subject in the fifth year.

Instructor: Wear.

Ma. 106 a, b, c. INTRODUCTION TO THEORY OF FUNCTIONS OF REAL VARIABLES. 5 units; first, second, and third terms. Required for graduation (B.S.) in mathematics.

Postulational treatment of real number system, descriptive properties of point sets, continuous and discontinuous functions, derivatives and differentials. Riemann integration, functions of several real variables, implicit functions.

Instructors: Michal, Ward.

Ma. 107. CONFORMAL REPRESENTATION. 9 units (3-0-6), second term. Prerequisites: Ma. 8, 10.

Riemann's problem, work of Schwarz and Christoffel. Applications to physical problems. Associated variation problems.

Instructor: Ward.

Ma. 109 a, b, c. INTRODUCTION TO MATHEMATICAL ANALYSIS. 9 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Primarily for experimental physicists and engineers.

Instructor: Bell.

Ma. 110 a, b, c. INTRODUCTION TO THEORY OF NUMBERS. 6 units; first, second, and third terms.

Prerequisite (third term): Reading knowledge of German.

This course will cover selected topics in elementary number theory.

Texts: Dickson's Introduction to Theory of Numbers; Landau's Vorlesungen.

Instructor: Ward.

Ma. 111. Elementary Theory of Tensors. 9 units.

Prerequisites: Ma. 8, 10.

Fundamental properties of tensors, differential forms, covariant differentiation, geodesic coordinates, Riemannian differential geometries. Instructor: Michal.

Ma. 113 a, b, c. GEOMETRY. 12 units; first, second, and third terms. Prerequisite: Ma. 2 a, b, c, d.

Algebraic geometry; projective geometry; differential geometry; tensor analysis and its applications to numerous geometrical problems; non-Euclidean geometry; Riemannian differential geometry; geometry of dynamics; hyperspace; elementary group theory and its geometrical applications.

Texts: McConnell, Applications of the Absolute Differential Calculus; Eisenhart, Riemannian Geometry; collateral reading.

Instructor: Michal.

MATHEMATICS

Ma. 114. MATHEMATICAL ANALYSIS. 12 units; first, second, and third terms.

This course will be offered every alternate year, and covers essentially the same topics as Ma. 201.

Prerequisites: Ma. 8, 10, and reading knowledge of German.

(Not to be given in 1936-1937.)

Instructor: Ward.

Ma. 118 a, b. INTRODUCTION TO STATISTICS. 3 units; first and second terms.

Prerequisite: At least a year of calculus, and a laboratory course in some science.

First term: Curve fitting by moments, correction for lack of high contact and for histogram group, the Pearson family of frequency curves, including the "normal" curve. Second term: Continuation of frequency curves, tests of goodness of fit, cycle analysis. Arrangements will be made to assist students who wish to carry the work further.

Instructor: Alter.

GRADUATE SUBJECTS

Note: For all courses numbered above 200, except 201a, a reading knowledge of French and German is required.

Ma. 201 a, b, c. MODERN ANALYSIS. 15 units; first, second, and third terms.

Prerequisites: Ma. 8, 10.

Theory of convergence, integration and residues, expansions of functions in infinite series, asymptotic and divergent series. Fourier series. Differential equations and function theory, integral equations, the gamma function and the zeta function, the hypergeometric function and related functions of mathematical physics, elliptic functions, ellipsoidal harmonics.

Note: The first term will satisfy the requirement in Complex Variable for those taking a minor in mathematics.

Instructor: Bateman.

Ma. 202 a, b, c. MODERN THEORY OF DIFFERENTIAL EQUATIONS. 12 units; first, second, and third terms.

Prerequisites: Ma. 10, 107, and reading knowledge of German.

Expansion of functions in series, asymptotic expansions. Linear differential equations in complex domain. Elementary methods of integration. General theory of linear differential equations and their solution by definite integrals and contour integrals. Classification of linear differential equations of the second order.

Instructor: Ward.

Ma. 204 a, b, c. GEOMETRICAL TRANSFORMATIONS AND INVARIANTS. 15 units; first, second, and third terms.

Prerequisite: Graduate standing.

Linear and bilinear transformations of one variable. Simple algebraic invariants. General theory of linear transformations and their invariants. Conformal transformations. Birational transformations. Contact transformations.

Instructor: Bateman.

Ma. 205 a, b, c. THEORY OF FUNCTIONS. 15 units; first, second and third terms.

Theory of convergence and infinite processes, properties of continuous and discontinuous functions, functions of limited variation, selected topics on analytic functions, point sets, measure of point sets, Stieltjes integrals, Lebesgue integrals, Fourier series and integrals, orthogonal functions, convergence in the mean, geometry of Hilbert space.

Text: Titchmarsh, The Theory of Functions. Instructor: Michal.

Ma. 209 a, b, c. FUNCTIONALS AND FUNCTIONAL EQUATIONS. 15 units; first, second, and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Analysis.

Functional operations; permutable functions, functions of composition; integral equations, integro-differential equations; differentials of functionals, functional equations with functional derivatives; infinite matrices; Stieltjes and Lebesgue integrals; abstract spaces.

Instructor: Michal.

Ma. 251 a. SEMINAR (I) IN ALGEBRA AND THE THEORY OF NUMBERS. 9 units, third term.

Prerequisite: Graduate standing.

Ma. 251 b. THEORY OF ALGEBRAIC NUMBERS. 9 units; third term. Alternates with Ma. 251a.

Prerequisite: Graduate standing.

Instructor: Bell.

172

Ma. 251 c, d. MATHEMATICAL LOGIC. 15 units; first and second terms. Instructor: Bell.

Ma. 252 a, b, c. SEMINAR IN CONTINUOUS GROUPS. 9 units; first, second, and third terms.

Prerequisite: Graduate standing in Mathematics.

Lie's theory of r-parameter groups; differential geometry of the group manifold. Groups of functional transformations; invariant functionals; differential geometries of function spaces.

Instructor: Michal.

Ma. 254 a, b, c. SEMINAR IN MODERN THEORIES OF INTEGRATION. 6 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Function Theory.

Stieltjes and Lebesgue integrals with applications to the algebra and geometry of functionals.

Instructor: Michal.

Ma. 255 a, b, c. METHODS OF MATHEMATICAL PHYSICS. 15 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Integral equations in which the kernel is a Green's function, Fourier series and integrals, Sturm-Liouville functions. Methods of Volterra, Fredholm and Hilbert for dealing with integral equations, Laplace's type of equation and the Heaviside calculus, calculus of variations, matrices and bilinear forms. Partial differential equations and the related simple solutions. Expansions in series of orthogonal functions.

Instructor: Bateman or Ward.

Ma. 256 a, b, c. MODERN DIFFERENTIAL GEOMETRY. 9 units; first, second, and third terms.

Prerequisite: Graduate standing.

Riemannian and Non-Riemannian geometries. Theory of parallel displacement of tensors. Affine differential geometry. Projective differential geometry. Continuous groups and their applications to geometry. Contemporary researches in differential geometry.

Instructor: Michal.

Ma. 257 a, b, c. SEMINAR IN ABSTRACT SPACES. 6 units; first, second and third terms.

Prerequisite: Graduate standing.

Metric spaces, linear vector spaces; topological spaces; abstract polynomials; general function theories; analysis and geometry in abstract spaces; connections with abstract algebra and the theory of functionals; analysis of selected papers of Frechet, Riesz and Banach; contemporary researches; applications to mathematical problems in modern theoretical physics.

Instructor: Michal.

Ma. 258 a, b, c. PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS. 12 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Illustration of general methods by consideration of ordinary linear equations. The simple wave-equation, the potential equation. Applications of the integral theorems of Stokes and Green. Reduction to variation problems and the solution of such problems by direct methods. Use of difference equations to obtain approximate solutions. Use of simple solutions expressed as products. Properties of the special functions introduced in this way. Solution of initial and boundary problems by various methods.

Instructor: Bateman.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN

Associate Professor: S. Stuart Mackeown

Assistant Professors: Frederick C. Lindvall, Francis W. Maxstadt

UNDERGRADUATE SUBJECTS

EE. 2. DIRECT CURRENTS. 9 units (3-0-6); second term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.

Theory and practice of direct current motors and generators. Fundamental to courses in operation and design of electrical apparatus. Numerous problems are solved.

Text: Principles of Direct Current Machines, Langsdorf.

Instructor: Maxstadt.

EE. 3. DIRECT CURRENT LABORATORY. 6 units (0-3-3); second term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; and registration for EE. 2.

Uses of measuring instruments, operation of direct current motors and generators, and determination of their characteristics.

Text: Laboratory notes.

Instructors: Maxstadt, Browne, Griest, Widess.

EE. 4. ALTERNATING CURRENTS. 9 units (3-0-6); third term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2.

Elementary study of alternating currents by analytical and graphical methods; alternating current machinery. The effect of inductance, capacitance, and resistance loads. Numerous problems are worked dealing with reactive circuits; resonance; coils in series and multiple; single and polyphase alternators; single and polyphase systems; synchronous motors; transformers; induction and single phase motors.

Text: Alternating Currents, Magnusson.

Instructor: Maxstadt.

EE. 5. Alternating Current Laboratory. 6 units (0-3-3); third term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2, 3, and registration for EE. 4.

Uses of alternating current indicating instruments and oscillograph operation of alternators, induction and synchronous motors and transformers; determination of characteristics of these machines.

Text: Laboratory Notes.

Instructors: Maxstadt, Griest, McRae, Widess.

EE. 6 a, b. ELECTRICAL MACHINERY. 6 units (2-0-4) second term; 9 units (3-0-6) third term.

Prerequisites: EE. 2, 3, 4, and 5.

Further study of direct current and alternating current machinery with particular emphasis on application; short transmission lines; short circuit currents; protective devices.

Texts: Principles of Direct Current Machines, Langsdorf; Alternating Currents, Magnusson; Problems in Electrical Engineering, Lyon.

Instructor: Lindvall.

EE. 7. ELECTRICAL LABORATORY. 9 units (0-3-6); third term.

Prerequisites: EE. 2, 3, 4, 5, 6; Ph. 7.

A continuation of EE. 3 and 5. Efficiency tests of alternating current machinery. Graphic analysis of alternator performance; operation of transformers, alternators and direct current machines in parallel; communication circuit testing; use of electronic devices; writing of engineering reports.

Text: Laboratory Notes.

Instructors: Maxstadt, Griest.

EE. 8. DIRECT CURRENTS. 7 units (3-0-4); first or second term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.

An abridged course in direct currents and direct current machinery designed to acquaint in an objective manner students, not majoring in electrical engineering, with electrical theory through its practical applications to circuits and machines.

Text: Principles of Electrical Engineering, Blalock.

Instructors: Maxstadt, Browne, Griest, Widess.

EE. 9. DIRECT CURRENT LABORATORY. 5 units (0-3-2); first or second term.

An abridged course for other than Electrical Engineering students. Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; registration for EE. 8. Text: Laboratory notes.

Instructors: Maxstadt, Browne, Griest, McRae, Widess.

EE. 10. ALTERNATING CURRENTS. 7 units (3-0-4); second or third term.

Prerequisites: EE. 8 and 9.

An abridged course in alternating currents and alternating current machinery similar to EE. 8.

Text: Principles of Electrical Engineering, Blalock. Instructors: Maxstadt, Browne, McRae.

EE. 11. ALTERNATING CURRENT LABORATORY. 5 units (0-3-2); second or third term.

Prerequisites: EE. 8 and 9 and registration for EE. 10.

An abridged course for other than Electrical Engineering students. **Text:** Laboratory notes.

Instructors: Maxstadt, Griest, Widess.

EE. 12. ELECTRIC CIRCUITS. 12 units (3-0-9); first term.

Prerequisites: EE. 2, 3, 4, 5.

A course of study involving the calculation of voltage, current, and power in electrical circuits by the symbolic or complex method.

Text: Principles of Alternating Currents, Lawrence; Problems in Alternating Currents, Lyon.

Instructors: Sorensen, Ramo.

EE. 70 a, b, c. Engineering Conference. 2 units (1-0-1); first, second and third terms.

Prerequisites: EE. 2, 3, 4, 5

Presentation and discussion of new developments in the industry. Review of current literature.

Instructors: Sorensen, Lindvall, Mackeown, Maxstadt.

FIFTH-YEAR SUBJECTS

EE. 120. Alternating Current Analysis. 12 units (4-0-8); first term.

Prerequisites: EE. 7 and preceding courses.

Advanced study of magnetic and electric circuits. Solution of problems involving the symbolic method and complex notation; symmetrical components; analysis of electromotive force and current, nonsinusoidal wave forms; analysis of oscillograms.

Texts: Alternating Current Phenomena, Steinmetz; Problems in Electrical Engineering, Lyon.

Instructor: Sorensen.

EE. 191 a, b, c. ALTERNATING CURRENT LABORATORY. 6 units (0-3-3); first, second and third terms.

Prerequisites: EE. 7 and preceding courses.

Complete tests of the induction motor; the operation of transformers in parallel; study of polyphase connections; photometric measurements; use of the oscillograph; calibration of watt-hour meters and relays; high voltage tests of insulation.

Text: Advanced Laboratory Notes.

Instructor: Maxstadt.

EE. 122. Advanced Alternating Current Machinery. 12 units; (4-0-8); second term.

Prerequisites: EE. 120 and preceding courses.

An advanced study of the alternator, the induction motor and the stationary transformer, with particular emphasis on problems involving polyphase polarity, together with single and polyphase multiple circuit.

Texts: Principles of Alternating Current Machinery, Lawrence; Problems in Alternating Current Machinery, Lyon.

Instructor: Sorensen.

EE. 128. ELECTRIC TRACTION. 6 units (2-0-4); second term.

Prerequisites: EE. 2, 4, 6.

The electric railway, traffic studies and schedules, selection of equipment in rolling stock, location and equipment of sub-stations, comparison of systems and power requirements for operation of electric cars and trams.

Text: Railway Engineering, Harding.

Instructor: Maxstadt.

EE. 130. ELECTRIC LIGHTING AND POWER DISTRIBUTION. 6 units (2-0-4); third term.

Prerequisites: EE. 2, 4, 6.

Electric distribution and wiring; calculation of simple alternating current circuits; installation and operation costs and selling price of electric power.

Text: Electrical Distribution Engineering, Seelye.

Instructor: Maxstadt.

EE. 144. TRANSMISSION LINES. 12 units (4-0-8); third term.

Prerequisites: EE. 122 and preceding courses.

Determination of economic voltage for transmission lines; line performance and protection; elementary transient phenomena; use of hyperbolic functions in line calculations.

Instructor: Lindvall.

EE. 148. Specifications and Design of Electrical Machinery. 6 units (4-0-2); first term.

Prerequisites: EE. 7 and preceding courses.

Preparation of specifications and design calculations for alternating and direct current machinery.

Text: Electrical Machine Design, Gray. Instructor: Sorensen.

EE. 152. DIELECTRICS. 6 units (2-0-4); third term.

Prerequisites: EE. 122 and preceding courses.

A study of electric fields in insulations, particularly air, and the effects on sparking voltage of the sparking distance, atmospheric pressure and humidity; corona phenomena; high frequency voltages; characteristics of commercial insulations.

Text: Dielectric Phenomena in High Voltage Engineering, Peek. Instructors: Sorensen, Ramo.

EE. 156. ELECTRICAL COMMUNICATION. 6 units (2-0-4); first term. Prerequisites: EE. 2, 3, 4, 5.

A study of modern means of communication with special emphasis on recent developments.

Instructor: Mackeown.

EE. 160. ELECTRIC TRANSIENTS. 6 units (2-0-4); second term. Prerequisites: EE. 120 and preceding courses.

A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors; with special emphasis on the use of differential equations for solving circuit problems.

Instructor: Mackeown.

EE. 162. VACUUM TUBES. 12 units (4-0-8); third term.

Prerequisites: EE. 6 and preceding courses.

Fundamental theory, and uses as detectors, amplifiers, and oscillators. Special uses of vacuum tubes in both radio and line communication.

Instructor: Mackeown.

EE. 163. RADIO. 9 units (3-0-6); first term.

Prerequisite: EE. 162.

Elementary course dealing with fundamentals of Radio Transmission.

Text: Radio Engineering, Terman.

Instructors: Mackeown, Pierce.

ADVANCED SUBJECTS

EE. 200. Advanced Work in Electrical Engineering.

Special problems relating to electrical engineering will be arranged to meet the needs of students wishing to do advanced work in the field of electricity. The Institute is equipped to an unusual degree for the following lines of work: Theory of Electrical Machine Design, Electric Transients, and High Voltage Engineering Problems, under the direction of Professors R. W. Sorensen and F. C. Lindvall; Electrical Engineering Problems using vacuum tubes under the direction of Professor S. S. Mackeown; Electrical Engineering Problems relating to the distribution and uses of electric power for lighting and industrial uses under the direction of Professor F. W. Maxstadt.

EE. 220. RESEARCH SEMINAR IN ELECTRICAL ENGINEERING. 2 units required; additional units based on work done. First, second, and third terms.

Meets once a week for discussion of work appearing in the literature and in progress at the Institute. All advanced students in Electrical Engineering and members of the Electrical Engineering staff are expected to take part.

Instructors: Sorensen, Mackeown, Maxstadt, and Lindvall.

EE. 221. TRANSMISSION LINE PROBLEMS. 15 units.

A study of transmission line transient problems, inductive interference, power limit analysis, etc.

Instructor: Sorensen.

EE. 223 a, b. ELECTRIC STRENGTH OF DIELECTRICS. 15 units; second and third terms.

A study of the effect of high potentials applied to dielectrics.

Text: Theory of Dielectrics, Schwagen-Sorensen.

Instructors: Sorensen, Ramo.
EE. 224 a, b, c. VACUUM TUBE AND RADIO FREQUENCY CIRCUITS. Units to be based on work done; first, second and third terms.

A study of the literature on vacuum tube circuits. Experimental work with oscillators, transmitters, and receivers.

Instructor: Mackeown.

EE. 225. PRINCIPLES OF ELECTRICAL DESIGN. 15 units; first term.

A discussion and calculation course in the analysis of the principles and methods used in the design of electrical machinery.

Instructors: Sorensen, Maxstadt.

EE. 226 a, b, c. ENGINEERING MATHEMATICAL PHYSICS. 15 units (3-0-12); first, second, and third terms.

Prerequisites: B.S. in Engineering; Differential Equations, Ma. 10 or Ma. 11.

This course is designed to develop the correlation of mathematics and physics with problems in engineering design and application. The following subjects will be treated in detail: mechanical vibrations, oscillations in electro-mechanical systems, short circuit forces, power system transients, electric motors applied to variable or pulsating loads, heat transfer and transient heat flow. The principle of constant flux linkage in electrical transient analysis; solution of mechanical problems by electrical methods; application of Heaviside operational calculus to mechanical and thermal problems.

Instructor: Lindvall.

EE. 227. OPERATIONAL CIRCUIT ANALYSIS. 6 units (2-0-4); third term. An introduction to the solution of circuit problems by the operational method.

Instructors: Mackeown, Widess.

EE. 228. CONDUCTION OF ELECTRICITY IN GASES, units to be arranged. Given first, second, and third terms in alternate years.

Text: Selected topics in glow arcs and spark discharges.

Instructors: Mackeown, Browne.

EE. 229. ADVANCED CIRCUIT ANALYSIS. 12 units (3-0-9); first, second and third terms.

Development of circuit equations from Maxwell's equations; application of Maxwell's equations to circuits at high frequency, filter circuits, symmetrical components, tensor analysis.

Instructor: Mackeown.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

CHEMISTRY

PROFESSORS: ARTHUR A. NOYES, STUART J. BATES, JAMES E. BELL, WILLIAM N. LACEY, LINUS PAULING, RICHARD C. TOLMAN

Associate Professors: Roscoe G. Dickinson, Howard J. Lucas, Don M. Yost

RESEARCH ASSOCIATES: JOSEPH B. KOEPFLI, E. A. MIRSKY

Assistant Professors: Richard McLean Badger, Arnold O. Beckman, Ernest H. Swift

UNDERGRADUATE SUBJECTS

Ch. 1 a, b, c. CHEMISTRY. 12 units (3-6-3); first, second, and third terms.

Lectures, recitations and laboratory practice. The class and laboratory work in the first term deals with volumetric analysis, solubility effects, the ionic theory, and equilibria in solutions, and in the second term with qualitative analysis; and in the third term the laboratory work consists of selected inorganic preparations and the lectures and classroom exercises of a survey of descriptive inorganic chemistry.

Texts: Noyes, Chemistry of Solutions; A. A. Noyes, Qualitative Analysis; McCuthen, Seltz and Warner, General Chemistry.

Instructors: Bell, Beckman, and Teaching Fellows.

Ch. 6. ENGINEERING CHEMISTRY. 9 units (3-0-6); first term.

Prerequisite: Ch. 1 a, b, c.

Reading, discussion and problems dealing with the application of chemical principles to engineering problems and the relations of engineering to the chemical industries.

(Not offered in 1935-1936.)

Text: Leighou, Chemistry of Engineering Materials. Instructor: Lacey.

Ch. 12 a, b. ANALYTICAL CHEMISTRY. 10 units (2-6-2); first and second terms.

Prerequisite: Ch. 1 c.

Laboratory practice in the methods of gravimetric and volumetric, and advanced qualitative analysis, supplemented by lectures and problems in which the principles involved in the laboratory work are emphasized.

Text: Swift, Analytical Chemistry. Instructor: Swift.

Ch. 12 c. ANALYTICAL CHEMISTRY AND CHEMISTRY REVIEW. 10 units (2-6-2), third term.

Prerequisite: Ch. 12 b.

A study of special methods of chemical analysis, including electrometric methods and analyses of selected alloys and minerals. Students are assigned individual problems for investigation. The class exercises are devoted to a discussion and review of the general principles of analytical and inorganic chemistry. The examination in this subject covers the chemistry work of the whole sophomore year. To be admitted in the junior year to the Option in Chemistry or in Applied Chemistry students must pass this subject satisfactorily.

Instructor: Swift.

Ch. 13 a, b. INORGANIC CHEMISTRY. 4 units (2-0-2); third and first terms.

Prerequisite: Ch. 12 b, 21 a, b.

The chemical and physical properties of the elements are discussed with reference to the periodic system and from the view-points of atomic structure and radiation-effects. Such topics as coordination compounds, the liquid ammonia system, the compounds of nitrogen, the halides, and selected groups of metals are taken up in some detail. The class work is supplemented by problems which require a study of current literature.

Instructor: Yost.

Ch. 14 a, b, c. INORGANIC CHEMISTRY LABORATORY. 8 units (0-8-0), third term; 5 units (0-5-0), first term; 8 units (0-8-0), second term.

Prerequisite: Ch. 12 c, 21 a, b.

This subject consists of laboratory work upon selected research problems in inorganic chemistry, often in relation to the rarer elements.

Instructors: Swift, Yost.

Ch. 16. INSTRUMENTAL ANALYSIS. 8 units (0-6-2); first term. Prerequisite: Ch. 12 c.

Laboratory practice designed to familiarize the student with special

analytical apparatus and methods, used both for process control and for research.

Text: Lacey, Instrumental Methods of Chemical Analysis. Instructor: Lacey.

Ch. 21 a, b, c. CHEMICAL PRINCIPLES. 10 units (4-0-6); first, second and third terms.

Prerequisites: Ch. 12 b; Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

Conferences and recitations dealing with the general principles of chemistry from an exact, quantitative standpoint, and including studies on the elements of thermodynamics; the pressure-volume relations of gases; on vapor-pressure, boiling point, freezing point, and osmotic pressure of solutions; on the molecular and ionic theories; on electrical transference and conduction; on chemical and phase equilibria; on thermochemistry, and the elements of thermodynamic chemistry and of electrochemistry. A large number of problems are assigned to be solved by the student.

Text: Noyes and Sherrill, Chemical Principles.

Instructors: Bates, Dickinson.

Ch. 22 a, b. THERMODYNAMIC CHEMISTRY. 6 units (2-0-4); first and second terms.

A continuation of subject Ch. 21, given in much the same way. The topics considered include reaction rate and a further study of electrochemistry and thermodynamic chemistry. Practice is given in the computation of free energies, activities and entropies of typical substances.

Text: Noyes and Sherrill, Chemical Principles, and mimeographs.

Instructor: Bates.

Ch. 23 a, b. CHEMICAL PRINCIPLES. 10 units (4-0-6); second and third terms.

Prerequisite: Ch. 21 a.

A selection of topics from Ch. 21 b, c, and from Ch. 22 a, b. This is a continuation of Ch. 21 a, adapted to the needs of Science Course students in the Physics, Geology, and Biology Options.

Text: Noyes and Sherrill, Chemical Principles, and mimeographs.

Instructor: Dickinson.

Ch. 26 a, b. PHYSICAL CHEMISTRY LABORATORY. 8 units (0-6-2) or 4 units (0-3-1) second term; and 4 units (0-3-1) third term.

Laboratory exercises to accompany Ch. 21.

Text: Sherrill, Laboratory Experiments on Physico-Chemical Principles.

Instructor: Bates.

Ch. 29. COLLOID AND SURFACE CHEMISTRY. 8 units (3-0-5); third term.

Prerequisite: Ch. 22.

Class-room exercises with outside reading and problems, devoted to the properties of surfaces, adsorption, contact catalysis, and the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired.

Text: Thomas, Colloids, and mimeographed notes. Instructor: Badger.

Ch. 41 a, b, c. ORGANIC CHEMISTRY. 8 units (3-0-5), first and second terms; 6 units (2-0-4), third term.

Prerequisite: Ch. 12 c.

Lectures and recitations treating of the classification of carbon compounds, the development of the fundamental theories, and the characteristic properties of the principal classes including hydrocarbons, alkyl halides, alcohols, acids, ethers, esters, amines, carbohydrates, aromatics.

Text: Lucas, Organic Chemistry.

Instructor: Lucas.

Ch. 43. ORGANIC CHEMISTRY. 10 units (2-6-2); third term.

Prerequisites: Ch. 1 a, b, c.

Lectures and recitations, accompanied by laboratory exercises, dealing with the synthesis and the physical and chemical properties of the more important compounds of carbon.

Texts: Outlines in Organic Chemistry, Moore and Hall; Laboratory Experiments in Organic Chemistry, Adams and Johnson.

Instructor: Wheland.

Ch. 46 a, b. ORGANIC CHEMISTRY LABORATORY. 9 units (0-9-0) or 12 units (0-12-0), first term; 6 units (0-6-0) or 9 units (0-9-0), second term. Prerequisite: Ch. 12.

Laboratory exercises to accompany Ch. 41, a, b. The preparation and purification of carbon compounds and the study of their characteristic properties. Qualified students may pursue research work.

Text: Lucas, Mimeographed Notes.

Instructors: Lucas, Wilson, and Teaching Fellows.

Ch. 61 a, b, c. INDUSTRIAL CHEMISTRY. 6 units (2-0-4) first and third terms; 4 units (2-0-2) second term.

Prerequisites: Ch. 21, a, b.

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.

Text: Read, Industrial Chemistry.

Instructor: Lacey.

Ch. 63 a, b. CHEMICAL ENGINEERING THERMODYNAMICS. 6 units (2-0-4); second and third terms.

Prerequisite: Ch. 21 a.

Class exercises and problems in engineering thermodynamics studied from the point of view of the chemical engineer.

Text: Goodenough, Principles of Thermodynamics.

Instructor: Lacey.

Ch. 70-73. CHEMICAL RESEARCH.

Opportunities for research are afforded to undergraduate students in all the main branches in chemistry; thus, in analytical or inorganic chemistry (Ch. 70), in physical chemistry (Ch. 71), in organic chemistry (Ch. 72), and in applied chemistry (Ch. 73). Such research may be taken as electives by students in honor standing in the sophomore and junior years; and every candidate for a degree in the Chemistry Option is required to undertake in his senior year an experimental investigation of a problem in chemistry. A thesis embodying the results and conclusions of this investigation must be submitted to the faculty not later than one week before the degree is to be conferred.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ch. 152. COLLOID AND SURFACE CHEMISTRY. 8 units; third term.

Lectures and classroom discussions with outside reading and problems, devoted to the general principles relating to surface-tension, adsorption and the general properties of surfaces, and to disperse systems and the colloidal state.

Text: Mimeographed Notes.

Instructor: Badger.

186

Ch. 153 a, b. THERMODYNAMIC CHEMISTRY. 6 units; first and second terms.

This course is the same as Ch. 22 a, b.

Text: Chemical Principles, Noyes and Sherrill, and mimeographs.

Instructor: Bates.

Ch. 154 a, b. STATISTICAL MECHANICS (Seminar). 6 units; first and second terms.

A discussion of statistical mechanics and its applications to physics and chemistry. The topics treated will include a sufficient exposition of classical and quantum theory mechanics to serve as a foundation for statistical mechanics; applications to specific heats, chemical equilibria, absorption and emission of radiation, collisions of the first and secondkinds, and the rates of physical chemical processes; and a discussion of Boltzmann's H-theorem and the relations between statistical mechanics and thermodynamics.

Text: Statistical Mechanics with Applications to Physics and Chemistry, Tolman.

Instructor: Tolman.

Ch. 155 a, b, c. THE NATURE OF THE CHEMICAL BOND. 6 units; first, second and third terms.

This course comprises the detailed non-mathematical discussion of the electronic structure of molecules and its correlation with the chemical and physical properties of substances. It is planned that the course will be given in 1935-6, and every third year thereafter.

Instructor: Pauling.

Ch. 156 a, b, c. INTRODUCTION TO WAVE MECHANICS, WITH CHEMICAL Applications. 9 units; first, second and third terms.

A review of Lagrangian and Hamiltonian mechanics and of the old quantum theory is first given, followed by the discussion of the development and significance of the new quantum mechanics and the thorough treatment of the Schrödinger wave equation, including its solution for many simple systems such as the rotator, the harmonic oscillator, the hydrogen atom, etc. During the second and third terms various approximate methods of solution (perturbation theory, the variation method, etc.) are discussed and applied in the consideration of the resonance phenomenon, the structure of many-electron atoms and of simple molecules, the nature of the covalent chemical bond, the structure of aromatic molecules, and other recent chemical applications. It is planned that this course be given in 1936-7.

Text: Pauling and Wilson, Introduction to Quantum Mechanics, with Applications to Chemistry.

Instructor: Pauling.

Ch. 157 a, b, c. THE STRUCTURE OF CRYSTALS. 6 units; first, second and third terms.

The following topics are discussed:

The nature of crystals and X-rays and their interaction. The various experimental methods of investigation—Bragg, Laue, oscillation, Weissenberg, etc. The theory of space groups and the use of symmetry in the determination of the structures of crystals. The detailed study of representative structure investigations. The various known crystal structures and their relation to the physical and chemical properties of substances. The quantitative treatment of X-ray diffraction. Fourier-series methods of structure investigation.

It is planned that this course be given every third year, including 1937-38.

Instructors: Pauling, Sturdivant.

Ch. 158. PHOTOCHEMISTRY. 6 units; first term.

Lectures and discussions on photochemical processes, especially in their relations to quantum phenomena. The following topics will be included: the photochemical absorption law; the processes—excitation, dissociation, ionization—accompanying the absorption of radiation; subsequent processes including fluorescence and collisions of the second kind; photosensitization; quantum yield and its relation to photochemical mechanism; catalysis and inhibition; temperature coefficients of photochemical reactions.

Instructor: Dickinson.

Ch. 159a. KINETICS OF HOMOGENEOUS REACTIONS. 6 units; first term. Lectures and discussions relating to homogeneous chemical reactions and to statistical mechanical, and other theories of such reactions.

Instructor: Dickinson.

Ch. 159b. KINETICS OF HETEROGENEOUS REACTIONS. 6 units; second term.

Lectures, discussions and problems relating to adsorption and contact catalysis.

Instructor: Badger.

Ch. 160. INORGANIC CHEMISTRY. 4 units; third and first terms.

Selected groups of inorganic compounds will be considered from modern physico-chemical view-points; thus with reference to their physical properties, their thermodynamic constants (their heat-contents, freeenergies, and entropies), their rates of conversion into one another (including effects of catalysis and energy radiations), and their molecular structure and valence relations.

Instructor: Yost.

Ch. 161. ORGANIC CHEMICAL ANALYSIS. 9 units; third term.

A laboratory study of the class reactions of carbon compounds and practice in the methods of identifying unknown substances.

Instructor: Lucas.

Ch. 162 a, b, c. ORGANIC CHEMISTRY (Special Topics). 6 units; first, second and third terms.

A series of lectures and discussions on selected topics of organic chemistry that have special interest from theoretical, industrial, or biological view-points.

Instructors: Lucas, Mirsky, Wheland.

Ch. 163. Introduction to the Spectra of Molecules. 6 units; first term.

The theory of the structure of the spectra of both the diatomic and the simpler polyatomic molecules will be presented, and the transition rules and their relation to the symmetry elements of molecules will be discussed. Emphasis will be laid on the methods of interpreting and analyzing molecular spectra, and it will be shown how from an analysis one obtains information regarding the structure and other properties of a molecule of interest to the chemist. Problems will be given in the interpretation of actual data.

Instructor: Badger.

Ch. 166 a, b, c. CHEMICAL ENGINEERING. 12 units (3-0-9); first, second and third terms.

Prerequisites: Ch. 61; Ch. 63 a, b.

Problems and discussions designed to bring the student in touch with the problems involved in carrying out chemical reactions efficiently on a commercial scale. The basic operations of chemical industry (such as heat production, heat transfer, mixing, filtration, distillation) are studied both as to principle and practice.

Text: Walker, Lewis and McAdams, Principles of Chemical Engineering.

Instructor: Lacey.

Ch. 167. PHASE EQUILIBRIA IN APPLIED CHEMISTRY. 6 units (2-0-4); second term, alternate years.

Prerequisites: Ch. 21, 61.

Problems and discussions relating to industrial applications involving heterogeneous equilibria.

Instructor: Lacey.

Ch. 169. RESEARCH MANIPULATIONS. 3 units; first term.

Laboratory exercises in glass-blowing and machine shop operations for research students. Class-room discussions on topics of general interest for research in physical chemistry, such as high-vacuum technique, electrical apparatus including applications of vacuum tube circuits, and the measurement of pressure, temperature and radiant energy.

Students must obtain permission from the instructor before registering for this course as the enrollment is necessarily limited.

Instructor: Beckman.

Ch. 170-173. CHEMICAL RESEARCH.

Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical or inorganic chemistry (170), physical chemistry (171), organic chemistry (172), and applied chemistry (173).

The main lines of research now in progress are:

Ionized substances in relation to the ion attraction theory.

Free-energies, equilibria, and electrode-potentials of reactions.

Study of crystal structure and molecular structure by diffraction of X-rays and electron waves.

Rates of chemical reactions in relation to the quantum theory.

Application of quantum mechanics to chemical problems.

Mechanism of homogeneous reactions.

Chemical reactions produced by atoms and molecules excited by radiations.

Band spectra in their chemical relations. Isomerism in the ethylene series. Hydration of unsaturated compounds. Rates of absorption of gases by liquids. Solubility of gases in liquids at high pressures. Equilibria in saturated salt solutions. Electrolysis of copper leaching solutions. Thermodynamic studies of hydrocarbons.

For a fuller survey of the researches in progress, see Publications of the Gates Chemical Laboratory.

Ch. 174-179. CHEMICAL RESEARCH CONFERENCES.

Each 2 units; given all three terms, unless otherwise noted.

Ch. 174. INORGANIC AND PHYSICAL CHEMISTRY.

- Ch. 175. Organic Chemistry.
- Ch. 176. PHOTOCHEMISTRY.
- Ch. 177. CRYSTAL AND MOLECULAR STRUCTURE.
- Ch. 178. BAND SPECTRA AND MOLECULAR STRUCTURE. (First and second terms.)
- Ch. 179. APPLIED CHEMISTRY. (Second and third terms.)

These conferences consist of reports on the investigations in progress in the laboratory and on other researches which have appeared recently in the literature. They are participated in by all men engaged in related lines of research in the laboratory, and are conducted by the chemistry professors connected with the respective branches.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING*

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL ASSOCIATE PROFESSOR: WILLIAM W. MICHAEL Assistant Professor: Fred J. Converse

UNDERGRADUATE SUBJECTS

CE. 1. SURVEYING. 11 units (3-4-4); second or third term.

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, stadia surveys, calculation and balancing of traverses, use of calculating machines, topographic mapping and field methods.

Text: Surveying, Breed and Hosmer. Instructor: Michael.

CE. 2. ADVANCED SURVEYING. 12 units (3-6-3); first term. Prerequisite: CE. 1.

A continuation of CE. 1, covering topographic surveys, plane table surveys, base line measurements, triangulation, determination of latitude and a true meridian by sun and circumpolar star observations, curves, cross-section surveys and earthwork estimates, stream gauging, draughting room methods and mapping, and the solution of problems.

Text: Surveying, Breed and Hosmer.

Instructor: Michael.

CE. 3. PLANE TABLE SURVEYING. 8 units (1-6-1); third term.

A course offered primarily for students in geology but may be elected by arrangement with the department. Theory and use of the plane table as applied to geological surveys. The class devotes one entire day a week to field surveys over typical terrain completing a topographic map of the region covered.

Text: Surveying, Breed and Hosmer.

Instructor: Michael.

^{*}See Division of Physics, Mathematics and Electrical Engineering, pages 175-181, for subjects in Electrical Engineering.

CE. 4. HIGHWAY ENGINEERING. 6 units (3-0-3); second term. Prerequisite: CE. 1.

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.

Text: Highway Design and Construction, Bruce.

Instructor: Michael.

CE. 8 a. RAILWAY ENGINEERING. 6 units (3-0-3); first term.

Prerequisites: CE. 1, 2.

A study of economic railway location and operation; railway plant and equipment; signaling; the solution of grade problems.

Text: Elements of Railroad Engineering, Raymond.

Instructor: Thomas.

CE. 8 b. RAILWAY SURVEYING. 6 units (2-0-4); second term. Prerequisite: CE. 1.

The theory of railway, highway and ditch location and surveys; problems relating to curves, grades, earthwork and track layout, including a study of the mass diagram as applied to railway and highway earthwork.

Text: Railway Curves and Earthwork, Allen.

Instructor: Michael.

CE. 8 c. RAILWAY SURVEYING. 6 units (0-6-0); third term. Prerequisite: CE. 8 b.

The class devotes one entire day a week to field surveys of a railroad location, applying the principles as outlined under course CE. 8 b.

Text: Railway Curves and Earthwork, Allen.

Instructor: Michael.

CE. 9. ELEMENTS OF STRUCTURES. 12 units (3-3-6); second term.

Prerequisite: AM. 1 c.

An abridged course in design of simple structures of timber, steel, masonry, and reinforced concrete. Emphasis is placed upon methods and computations in numerous typical examples.

Text: Structural Design, Thomas.

Instructor: Michael.

CE. 10 a. THEORY OF STRUCTURES. 12 units (3-3-6); first term. Prerequisite: AM. 1 c.

Methods used in the calculation of stresses in and proportioning of beams, girders, and columns of timber, steel and concrete; study of the effects of moving load systems; graphic statics applied to roofs and bridges.

Text: Structural Theory, Sutherland and Bowman. Instructor: Martel.

CE. 10 b, c. THEORY OF STRUCTURES. 12 units (3-3-6), second term, and 9 units (3-0-6) third term.

Prerequisite: CE. 10 a.

A continuation of CE. 10 a, covering the computation of stresses in truss members, the design of structural parts, connections, portals, and bracing; a study of arch, cantilever, and continuous bridges; and deflection of trusses.

Text: Structural Design in Steel, Shedd. Instructor: Martel.

CE. 12. REINFORCED CONCRETE. 12 units (3-3-6); third term.

Prerequisites: AM. 1 c; CE. 10 a.

The theory of reinforced concrete design, with a study of the applications of this type of construction to various engineering structures.

Text: Principles of Reinforced Concrete Construction, Turneaure and Maurer.

Instructor: Martel.

CE. 14 a, b, c. ENGINEERING CONFERENCES. 2 units (1-0-1); first, second and third terms.

Conferences participated in by faculty and seniors of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences.

The technique of effective oral presentation of reports is emphasized through criticisms of the reports from the standpoint of public speaking by a member of the Department of English.

Instructors: Michael, Eagleson.

FIFTH-YEAR SUBJECTS

CE. 15. IRRIGATION AND WATER SUPPLY. 12 units (5-0-7); second term.

Prerequisite: Hy. 1.

A study of modern practice of the collection, storage and distribution of water for municipal, domestic and irrigation uses; design, construction and operation of systems; consideration of the conditions adapted to irrigation developments, dams, reservoirs, canals; laws pertaining to irrigation; the economic aspects of projects.

Text: Water Supply and Utilization, Baker and Conkling. Instructor: Thomas.

CE. 16. MASONRY STRUCTURES. 9 units (2-3-4); second term. Prerequisite: CE. 12.

Theory of design and methods of construction of masonry structures; foundations, dams, retaining walls, and arches.

Text: Design of Masonry Structures, Williams. Instructor: Martel.

CE. 17. SEWERAGE. 9 units (3-0-6); third term.

Prerequisite: Hy. 1.

Systems for the collection and disposal of sewage; the design of sewers and storm drains; inspection of local sewage disposal plants; the drainage of land; cost assessments.

Text: Sewerage and Sewage Disposal, Metcalf and Eddy. Instructor: Thomas.

CE. 21 a. STRUCTURAL DESIGN. 12 units (0-12-0); first term.

Prerequisites: CE. 10 a, b, c.

The design of a plate girder bridge and a truss bridge or a steel frame building; stress sheets and general drawings are made. Designing office practice is followed as affecting both computations and drawings. Instructor: Thomas.

CE. 21 b. STRUCTURAL DESIGN. 9 units (0-9-0); second term. Prerequisites: CE. 10 a, 12.

The design of a reinforced concrete building in accordance with a selected building ordinance, with computations and drawings.

Instructors: Thomas, Martel.

CE. 21 c. CIVIL ENGINEERING DESIGN. 9 units (0-9-0); third term. Prerequisites: CE. 15, 21 a, b.

Special problems including preliminary investigations of irrigation or water power projects; study of stream flow data, the effect of reservoir storage upon distributed flow, determination of size and type of economic development.

Instructor: Thomas.

CE. 23. STATICALLY INDETERMINATE STRUCTURES. 15 units, first term. A study of such structures as continuous spans, rigid frames and arches by the methods of least work or slope-deflections; analysis of secondary stresses.

Text: Continuous Frames of Reinforced Concrete, Cross and Morgan. Instructor: Martel. CE. 30 a, b, c. ENGINEERING SEMINAR. 2 units (1-0-1); first, second and third terms.

Conferences participated in by faculty and graduate students of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences, with special consideration given to the progress of research being conducted at the Institute.

ADVANCED SUBJECTS

Special problems in the various fields of civil engineering will be arranged to meet the needs of students wishing to do advanced work in this department. The following lines of work are possible. Stream Regulation and Utilization for Power, Irrigation, and Water Supply under the direction of Prof. Franklin Thomas; Advanced Structures under the direction of Prof. Martel; Sanitation and Sewerage under the direction of Profs. Thomas and Martel; Highways and Geodesy under the direction of Prof. Michael; Analysis of Earthquake Effects upon Structures under the direction of Professor Martel.

CE. 101 a, b. WATER POWER PLANT DESIGN. 10 units; first and second terms.

A design of a power plant in conformity with the conditions of head, flow, and load fluctuations at a particular site. Includes selection of number and type of units, design of water passages, and general structural features.

Instructor: Thomas.

CE. 105 b, c. STATICALLY INDETERMINATE STRUCTURES. 15 units; second and third terms.

A continuation of the study of indeterminate structures as begun in CE. 23, with the use of analytical and instrumental methods of solution. Instructor: Martel.

CE. 107 a, b, c. GEODESY AND PRECISE SURVEYING. 6 units; first, second and third terms.

Methods of triangulation and surveying over extended areas. The adjustment of triangulation systems, the adjustment of observations by the method of least squares. Map projections, precise leveling determination of a true meridian.

Instructor: Michael.

CE. 108. HIGHWAY PROBLEMS. Units to be based on work done. Cooperating with the Highway Research Board of the National Research Council, opportunities are offered for advanced studies in highway engineering. Arrangements may be made for special studies on subgrade materials, wearing surfaces, economics of vehicle operation, and allied subjects.

Instructor: Michael.

CE. 110 b, c. SEWAGE TREATMENT PLANT DESIGN. 10 units; second and third terms.

A design of treatment works for a selected community and site involving special conditions of location, volume, and character of disposal. Includes selection of process, arrangement of tanks and equipment, and general design of structures.

Instructor: Thomas.

CE. 111. WATER TREATMENT PLANT DESIGN. Units to be based upon work done; any term.

Preparation of a layout and design of the general features of a plant to effect the purification and softening of water as may be required in specific circumstances. Includes design of typical structural features of the plant.

Instructor: Thomas.

CE. 112. SANITATION RESEARCH. Units to be based upon work done; any term.

Exceptional opportunities in this field are available at the sewage treatment plant of the city of Pasadena, where the activated sludge process is in operation, supplemented by a rotary kiln drier for the reduction of sludge to commercial fertilizer.

Instructor: Thomas.

CE. 113. UNDERGROUND WATER INVESTIGATIONS. Units to be based upon work done; any term.

A study of the relation between rainfall, runoff, percolation, and accumulations of ground water. Investigation of the location, extent, and yield of underground reservoirs.

Instructor: Thomas.

CE. 114. ANALYSIS OF EARTHQUAKE EFFECTS UPON STRUCTURES. Units to be based upon work done; any term.

A comparison of analytical study and experimental effects of vibrations on simple structures with the effects of earthquakes upon buildings. Instructor: Martel.

. 6 which go and

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP Assistant Professor: Robert T. Knapp Instructors: Donald S. Clark, Ernest E. Sechler, Herman J. Stoever

UNDERGRADUATE SUBJECTS

ME. 1. MECHANISM. 9 units (3-3-3); first, second or third term. Prerequisites: Ma. 1 a, b, c, d; Ph. 1 a, b, c, d; D. 1, 4, 12 a, b.

An analytical study of constrained motion in machines and of the relations of machine elements. Desirable types of motion; displacements of machine parts using simple valve motions, cam actuating parts, and other reciprocating and oscillating machine members as examples. Velocity studies; average and instantaneous values; velocity analysis by vectors using centros; relative velocities; application of vectors to cyclic trains and other differential motions. Acceleration analysis; inertia forces. The various linkages and combinations of machine elements are introduced and used as a means of mastering the geometry of machine motion.

Text: Principles of Mechanism, Vallance and Farris. Instructors: Clapp, Freeman.

ME. 3. MATERIALS AND PROCESSES. 11 units (3-3-5); second or third term.

A study of the materials of engineering and of the processes by which these materials are made and fabricated. The fields of usefulness and the limitations of alloys and other engineering materials are studied, and also the fields of usefulness and limitations of the various methods of fabrication and of processing machines.

The class work is combined with inspection trips to many industrial plants. The student is not only made acquainted with the technique of processes but of their relative importance industrially and with the competition for survival which these materials and processes continually undergo.

Text: Materials and Processes, Clapp and Clark. Instructor: Clark.

ME. 5 a, b, c. MACHINE DESIGN. 9 units (2-3-4) first term; 12 units (3-3-6) second term; 9 units (0-9-0) third term.

Prerequisites: ME. 1; AM. 1 a, b.

Applications of mechanics of machinery and mechanics of materials to practical design and construction. Riveting and welding; boilers and plate vessels; bolts and screws; force and shrink fits; hydraulic cylinders; cylinders and cylinder heads for steam and gas engines; stuffing boxes and packing; pistons and piston rings; leaf springs, coil springs; piston pins; connecting rods and cross heads; cranks and crank-shafts; flywheels; spur gears; helical gears; bevel gears; worm gears; spiral gears; belting; pulleys; rope driving; chains; friction drives; wire rope and hoisting; plain bearings; ball bearings; roller bearings; shafts and couplings; clutches; brakes; high speed disks; piping. Also a study of manufacturing processes with especial reference to the economics of design.

Text: Design of Machine Elements, Faries. Instructor: Clapp.

ME. 8. MACHINE DESIGN. 12 units (3-3-6); first term.

Prerequisites: ME. 1; AM. 1 a, b.

An abbreviated course in machine design for aeronautical engineers. The energy and force problem; relations of stress and strain to failure and the determination of proper safety factors; straining actions in machines; stresses with complex loading; screws and screw fastenings; axles, shafting, and couplings; friction and lubrication; journals and bearings.

Text: Design of Machine Elements, Faries. Instructor: Sechler.

ME. 10. METALLURGY. 6 units (2-0-4); first term.

Prerequisites: ME. 3; Ch. 6.

A study of the principles underlying the heat treatment, properties, use, and selection of ferrous and non-ferrous alloys as applied to design. Text: Physical Metallurgy for Engineers, Clark.

Instructor: Clark.

ME. 15. HEAT ENGINEERING. 12 units (3-3-6); second or third term. Prerequisites: Ma. 2 a, b, c, d; ME. 1.

Principles of engineering thermodynamics; properties of gases; thermodynamic processes of gases; gas cycles; internal combustion engines; air compressors; and elements of different types of power plants. Inspection of local power plants, laboratory demonstration tests, and computing room exercises.

Text: Heat Power Engineering, Vol. I, Barnard, Ellenwood, and Hirshfeld.

Instructor: Stoever.

ME. 16. HEAT ENGINEERING. 12 units (4-0-8); third term. Prerequisite: ME. 15.

Additional work in thermodynamics; properties of vapors; thermodynamic processes of vapors; vapor cycles; steam engines; steam turbines.

Text: Heat Power Engineering, Barnard, Ellenwood, and Hirshfeld. Instructor: Daugherty.

ME. 17. HEAT ENGINEERING. 9 units (3-0-6); first term.

Prerequisite: ME. 16.

Heat transmission; fuels; combustion; flue gas analysis; steam generators; and steam generator accessories.

Text: Heat Power Engineering, Vol. II, Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 18. HEAT ENGINEERING. 10 units (3-0-7); third term.

Prerequisite: ME. 15.

An abridgement of ME. 16 for students in Electrical Engineering. Instructor: Daugherty.

ME. 19. HEAT ENGINEERING. 6 units (2-0-4); second term. Prerequisite: ME. 17.

Flow of compressible fluids; condensers; feed water heaters; water softening; mixtures of air and water vapor; atmospheric water cooling; heating and ventilating; refrigeration.

Text: Heat Power Engineering, Vol. III, Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 25. MECHANICAL LABORATORY. 6 units (0-3-3); third term.

Prerequisite: ME. 15.

Tests of steam engine, steam turbine, blower and gas engine, etc., for efficiency and economy.

Text: Power Plant Testing, Moyer.

Instructors: Knapp, Stoever, Budenholzer, Chivens.

ME. 26. MECHANICAL LABORATORY. 6 units (0-3-3); second term. Prerequisite: ME. 15.

Additional work in the laboratory on air compressors, fuel and oil testing, and special work on steam and internal combustion engines.

Text: Power Plant Testing, Moyer.

Instructors: Knapp, Stoever, Budenholzer, Chivens.

ME. 27. MECHANICAL LABORATORY. 9 units (0-3-6); first term. Prerequisites: ME. 15 and Hy. 1.

An abridgement of ME. 25 and Hy. 2 for students in Electrical Engineering.

Instructors: Knapp, Stoever, Budenholzer, Chivens, Ippen.

ME. 50 a, b, c. ENGINEERING CONFERENCES. 2 units (1-0-1); first, second and third terms.

Presentation and discussion of new developments in industry. Review of current literature.

Instructors: Daugherty, Huse.

FIFTH-YEAR AND ADVANCED SUBJECTS.

ME. 100. Advanced Work in Engineering.

In addition to the regular fifth-year and other advanced courses which are here outlined, the staff of the mechanical engineering department will arrange special courses or problems to meet the needs of advanced students.

ME. 101 a, b. Advanced Machine Design. 12 units, second and third terms.

Prerequisites: ME. 5, 10.

The student must possess a comprehensive knowledge of mechanics, of materials, and also of the physical properties of the more common materials of construction. Strength of material formulae are studied as to their authority and limitations, and their application is extended to cover such cases as curved bars, thin plates, energy loads, stress concentration around holes, key seats, etc.; dynamic stresses as in rotating disks and flywheels; critical speeds of shafting; bending of bars on elastic foundations. Many examples of evolved designs are studied to determine the considerations which have led to the design. Theory of strengths and their application to the study of designs which have failed in service.

Instructor: Clapp.

ME. 110 a, b, c. SCIENCE OF METALS. 6 units (3-3-0) each term. Prerequisite: ME. 10.

A study of modern engineering metals and alloys; their mechanical and physical properties, and the effects upon these properties brought about by the various processes of manufacture and fabrication. A study of the physical principles governing metallic behavior.

Text: Principles of Physical Metallurgy, Doan. Instructor: Clapp. ME. 111 a, b, c. METALLOGRAPHY LABORATORY. 6 units; first, second and third terms.

Prerequisite: ME. 110 a, b, c, or to be taken at the same time.

Pyrometry, thermal analysis, microscopy, preparation of metallographic specimens, photomicrography, structures of steels and cast irons, heat treatment of steel, structures and treatment of non-ferrous alloys, recrystallization and grain growth, macroscopy, inspection methods, special problems.

Instructor: Clark.

ME. 120. HEAT ENGINEERING. 12 units (3-0-9); first term. Prerequisite: ME. 17.

Advanced work in engineering thermodynamics; thermodynamic processes of actual gases with variable specific heats; complex power plant cycles; heat transmission; combustion; heat balance of boilers; and other applications to practical cases.

Instructor: Daugherty.

ME. 121 and 122. HEAT ENGINEERING. 12 units (2-0-10); second and third terms.

Prerequisite: ME. 120.

Advanced study of internal combustion engines of all types, steam turbines, heating and ventilating, refrigeration, air conditioning, and steam power plants. Either term may be taken independently of the other.

Instructor: Daugherty.

ME. 125. REFRIGERATION PLANTS. Units to be based on work done; any term.

Design of various types of refrigeration plants best adapted to different conditions of service.

Instructors: Daugherty, Knapp.

ME. 130. Advanced Mechanical Laboratory. 15 units (1-9-5); first term.

Prerequisites: ME. 17, 26.

Advanced work on steam turbines, internal combustion engines, lubrication, and similar subjects. Each problem will be studied in enough detail to secure a thorough analysis. Conference hour for progress discussion.

Instructor: Knapp.

ME. 132. ENGINE LABORATORY. 15 units; first, second and third terms.

Use of the dynamometer. Experimental work in engine performance, carburetion, ignition, fuel consumption, etc.

ME. 140 a, b. RESEARCH OR THESIS. 18 units; second and third terms. This work is arranged with the department to fit the needs and desires of the individual student.

ME. 150 a, b, c. Mechanical Engineering Seminar. 2 units each term.

Attendance required of graduate students in mechanical engineering. Conference on research work and reviews of new developments in engineering.

AERONAUTICS

PROFESSORS: HARRY BATEMAN, THEODOR VON KÁRMÁN Associate Professors: Arthur L. Klein, Clark B. Millikan Assistant Professors: Irving P. Krick, Arthur E. Raymond Instructors: W. A. Klikoff, Ernest E. Sechler

UNDERGRADUATE SUBJECTS

AE. 1. GENERAL AERONAUTICS. 9 units (3-0-6); second term. Prerequisites: Ph. 2 a, b, c, d.

Historical development. Elementary theory of airplane, balloon, and helicopter. Theory of model testing. Control and stability of aircraft. Survey of contemporary design.

Texts: Bedell, The Airplane; Monteith and Carter, Simple Aerodynamics and the Airplane.

Instructor: Klein.

AE. 2 a, b. AIRCRAFT STRUCTURES. 12 units; second and third terms. Prerequisite: AM. 1c.

A course adapted for aeronautical engineering students in the analysis of forces by analytical and graphical methods and the calculation of stresses in beams, girders, columns, shafts and simple trusses of timber, steel and light alloys; study of continuous beams; beams under combined lateral and axial loads; trusses with redundant members; effect of flexure and direct stress; deflections in beams and trusses; tapered columns; circular rings; thin wall structures; loads upon an airplane.

Text: Younger, Structural Design of Metal Airplanes.

Instructor: Klikoff.

See also Courses CE. 11 and ME. 8.

FIFTH-YEAR AND ADVANCED SUBJECTS

AE. 251 a, b, c. AERODYNAMICS OF THE AIRPLANE. 9 units, first, second, and third terms.

Prerequisites: AM. 1 a, b, c, AM. 3.

Airfoils, wings, and tail groups, stability and control, drag, performance and spinning.

Texts: Stalker, Principles of Flight; Younger and Woods, Dynamics of Airplanes; Wood, Technical Aerodynamics.

Instructor: Millikan.

AE. 252 a, b, c. AIRPLANE DESIGN. 12 units, first, second, and third terms.

Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

Beams, trusses, columns, and indeterminate structures, wing and fuselage structures, hulls and floats, monocoque construction. AE. 252 must be taken concurrently with or subsequently to 251.

Texts: Niles and Newell, Airplane Structures; Boyd, Strength of Materials.

Instructors: Sechler, Raymond.

AE. 253 a, b, c. AIRPLANE DESIGN AND TESTING PROCEDURE. 6 units, first, second, and third terms.

Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

253a, drafting room technique, factory methods, factory equipment, materials used; 253b, control systems, flap systems, landing gears, power plants, and non-structural components; 253c, performance prediction, performance reduction, flight testing.

Instructors: Klein, Raymond.

AE. 254 a, b, c. ADVANCED PROBLEMS IN AIRPLANE DESIGN. 9 units; first, second, and third terms.

Prerequisites: AE. 251, 252, 253. Instructor: Klein.

AE. 266 a, b. THEORETICAL AERODYNAMICS I. PERFECT FLUIDS. 12 units, first term; 9 units, second term.

Prerequisites: Ma. 14; Ma. 109 a, b, or EE. 226 a, b.

Hydrodynamics of perfect fluids as applied to aeronautics, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, airfoils, three dimensional wing theory, monoplanes, biplanes, interference.

Texts: Glauert, The Elements of Aerofoil and Airscrew Theory; Prandtl, Applications of Modern Hydrodynamics to Aeronautics.

Instructor: Kármán or Millikan.

AE. 267. THEORETICAL AERODYNAMICS II. REAL FLUIDS. 12 units, third term.

Prerequisites: AE. 266 a, b.

Hydrodynamics of viscous fluids, laminar motion in pipes and channels, turbulence and Reynolds' criterion, similarity laws, theory of drag, discontinuous flow and vortex streets, theory of skin-friction, boundary layer, general theory of turbulence.

Instructor: Kármán or Millikan.

AE. 268. HYDRODYNAMICS OF A COMPRESSIBLE FLUID. 12 units; one term.

Prerequisites: AE. 266 a, b.

Relation of the equations to the kinetic theory of gases, theory of jets and of the Venturi tube, motion with a velocity exceeding the velocity of sound, shock waves, cavitation.

Instructor: Bateman.

AE. 269 a, b, c. Advanced Problems in Theoretical Aerodynamics. 9 units; first, second, and third terms.

A seminar course in the applications of theoretical aerodynamics to aeronautical problems for students who have had AE. 266 and AE. 267.

Instructors: Kármán, Millikan.

AE. 270 a, b, c. ELASTICITY APPLIED TO AERONAUTICS. 12 units, first term; 6 units, second and third terms.

Prerequisites: Ma. 109 a, b, AM. 1 a, b, c, 3.

Analysis of stress and strain. Hookes law. Theory of bending and torsion. Stresses in thin shells. Theory of elastic stability. Vibrations and flutter.

Instructors: Kármán, Sechler.

METEOROLOGY

AE. 272 a, b, c. DYNAMIC METEOBOLOGY. 9 units (3-0-6); first, second, and third terms.

The application of hydrodynamics and thermodynamics to the study of atmospheric phenomena. Statics and kinematics of the atmosphere; general dynamics of air currents; energy of air movements, gusts, turbulence, etc.

Instructors: Kármán, Rockefeller.

AE. 273 a, b, c. SYNOPTIC METEOROLOGY. 12 units (4-0-8); first, second and third terms.

Application of the principles of dynamic meteorology to the study of the phenomena of the weather map. Modern theories on the structure of the extra-tropical cyclone, general circulation of the atmosphere, air masses, frontogenesis and frontolysis. Upper air soundings and their use in synoptic meteorology, identification of air masses by evaluation of upper air data and by other criteria. Detailed discussion of weather forecasting by means of frontal and air mass analysis, especially in connection with aircraft operations. Forecasting of local weather phenomena such as fogs, thunder storms, etc., effects of topography upon frontal movements and upon properties of air masses.

Instructor: Krick.

AE. 274 a, b, c. METEOROLOGICAL LABORATORY. 15 units; first, second and third terms.

Decoding and plotting of daily weather maps by frontal and air-mass analysis methods. Surface data augmented by all available upper-air information in order to obtain, as far as possible, three-dimensional analyses. The Department of Commerce teletype service is utilized and actual operating conditions simulated in the laboratory, including practice forecasts for selected areas, both of a general nature and of a more detailed nature in connection with forecasts for aviation. The laboratory work is supplemented by observational work carried on at the Institute's Marine Observatory at Long Beach, California.

Instructor: Krick.

AE. 275. STRUCTURE OF THE ATMOSPHERE. 3 units, third term.

Constituents of the atmosphere and their distribution. Theories underlying the probable structure and temperature of the stratosphere. Optics of the atmosphere and related phenomena.

Instructor: Gutenberg.

AE. 276. METEOROLOGICAL INSTRUMENTS. 6 units (6-0-0), first term.

Temperature measurements, including a study of mercury and other expansion thermometers, electrical thermometers; hygrometry; barometers; velocity measurements, including dynamic pressure and hot wire instruments, rain and snow gauges, cloud measurements; radiation measurements, including a study of sounding and pilot balloons and their equipment. Practical measurements are made at the Institute's Marine Observatory at Long Beach.

Instructors: Krick, Wood.

AE. 280 a, b. METEOROLOGICAL RESEARCH. Units to be determined; second and third terms.

Selected problems in meteorology research assigned to meet the needs of advanced students.

Instructors: Gutenberg, Krick.

AE. 290 a, b, c. AERONAUTICAL SEMINAR. 2 units; first, second and third terms.

Study and critical discussion of current contributions to aerodynamics and aeronautical engineering.

A.E. 291 a, b, c. METEOROLOGICAL SEMINAR. 2 units; first, second and third terms.

Weekly reviews and discussions of current meteorological literature and problems.

Instructors: Gutenberg, Krick.

Additional and supplementary courses will be offered as the need arises. Lectures will be given from time to time by visiting scientists and engineers from this country and Europe. Flying is not given officially at the Institute, but there are ample opportunities for a student to learn to fly at one of the neighboring flying fields.

APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR. Assistant Professor: Fred J. Converse

UNDERGRADUATE SUBJECTS

AM. 1 a, b. APPLIED MECHANICS. 14 units (4-3-7); first and second terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d; Ph. 1 a, b, c, 2 a, b, c, d. Action of forces on rigid bodies; composition and resolution of forces; equilibrium, couples, framed structures; cords and chains; centroids; displacement; velocity and acceleration; translation, rotation, and plane motion; moments of inertia; inertia forces; kinetic and potential energy; work and energy; impulse and momentum; impact; power; efficiency.

Text: Engineering Mechanics, Brown.

Instructors: Converse, Jennison, Mackintosh, McCann, Popoff.

AM. 1 c. STRENGTH OF MATERIALS. 14 units (4-3-7); third term. Prerequisite: AM. 1 a, b.

Elasticity and strength of materials of construction; theory of stresses and strains; elastic limit; yield point; ultimate strength; safe loads; repeated stresses; beams; cylinders; shafts; columns; riveted joints; structural shapes.

Texts: Strength of Materials, Boyd; and Carnegie Pocket Companion.

Instructors: Hinrichs, Converse, Jennison, Mackintosh, McCann, Popoff.

AM. 2 a, b. APPLIED MECHANICS AND STRENGTH OF MATERIALS. 12 units (4-0-8); first and second terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d; Ph. 1 a, b, c, 2 a, b, c, d. An abridged course for students electing the Applied Chemistry Option in the Science Course, condensing in the work of two terms as much as possible of the general field outlined above in AM. 1 a, b, c.

Texts: Engineering Mechanics, Brown; Strength of Materials, Boyd; and Carnegie Pocket Companion.

Instructor: Hinrichs.

AM. 3. TESTING MATERIALS LABORATORY. 6 units (0-3-3); second or third term.

Prerequisite: AM. 1 c.

Tests of the ordinary materials of construction in tension, compression, torsion, and flexure; determination of elastic limit; yield point, ultimate strength, and modulus of elasticity; experimental verification of formulas derived in the theory of strength of materials.

Text: Materials of Construction, J. B. Johnson.

Instructors: Converse and Schwartz.

ADVANCED SUBJECTS AM. 105. Soil MECHANICS. 9 units (3-0-6); any term.

A study of the physical and mechanical properties of soils, and the determination of principles which govern their behavior under load. The application of these principles to problems of foundations and of earthwork engineering.

Instructor: Converse.

ENGINEERING DRAWING

INSTRUCTORS: ERNEST E. SECHLER, H. J. STOEVER, NATHANIEL W. WILCOX

D. 1. FREEHAND DRAWING. 3 units (0-3-0); first term.

The study of geometrical forms and their representation by means of freehand perspective. Training in pencil rendering is given and the fundamental principles of perspective are illustrated by simple architectural and engineering studies. Emphasis is placed on careful observation and accurate drawing.

Instructor: Wilcox.

D. 2. ADVANCED FREEHAND DRAWING. Either 3 units (0-3-0) or 6 units (0-3-3); elective, second term.

Prerequisite: D. 1.

This course is similar to D. 1, but with advanced subject matter. The student is allowed, to a certain extent, to choose subjects for his work which are related to his chief field of interest.

Instructor: Wilcox.

Descriptive Geometry, D. 3 a, b, c, d and D. 4 are planned to cover a thorough study of shape description and representation. Especial emphasis will be placed upon the visualization of problems in order to develop three dimensional observation. The work will include practical as well as purely geometrical problems.

D. 3 a. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); second term.

The study of the graphical representation of three dimensional geometrical constructions by means of orthographic projection. The work includes principle, auxiliary and oblique views.

Text: Hood, Geometry of Engineering Drawing.

D. 3 b. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); third term.

Prerequisite: D. 3 a.

A continuation of D. 3 a, covering the geometrical relationships of lines and planes.

Text: Hood, Geometry of Engineering Drawing.

D. 3 c. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); first or second terms. Prerequisite: D. 3 b.

A continuation of D. 3 b, covering problems involving curved lines and the intersection and development of surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 3 d. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); second or third terms.

Prerequisite: D. 3 c.

A continuation of D. 3 c, covering more complicated problems involving single curved surfaces, warped and double curved surfaces, and mining problems.

Text: Hood, Geometry of Engineering Drawing.

D. 4. Advanced Descriptive Geometry. 6 units (0-6-0); elective any term.

Prerequisite: D. 3 a, b, c, d.

The study of lineal perspective and the execution of mechanical perspective drawings of machines, bridges, and other structures.

D. 5. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); third term.

Prerequisites: D. 3 a, b.

This course is planned primarily for geology students, and includes practical problems in mining and earth structures.

Text: Hood, Geometry of Engineering Drawing.

D. 6 a. ENGINEERING DRAWING. 6 units (0-6-0); first or second term. Prerequisite: D. 1, 3 a, b.

This course is designed to give the student a general knowledge of the most important types of engineering drawings. Instruction is given in the proper use of drafting equipment and in the fundamental principles of drafting and lettering. The accepted standards for both machine and structural drawing are given, and plates are drawn which illustrate the use of these standards. The student is also given basic training in making pictorial drawings and engineering charts and graphs.

Text: Svensen, Drafting for Engineers, second edition.

(Not offered in 1935-36.)

D. 6 b. ENGINEERING DRAWING. 6 units (0-6-0); second or third term.

Prerequisites: D. 1, 3 a, b, c, 6.

This is a continuation of the course described above.

Text: Svensen, Drafting for Engineers, second edition.

(Not offered in 1935-36.)

D. 7. ADVANCED ENGINEERING DRAWING. Maximum of 6 units. Elective, any term.

Prerequisites: D. 3 a, b, c, d, 6 a, b.

The study and execution of drawings of machines or equipment designed by upper-class students in the engineering department.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY Assistant Professor: Robert T. Knapp

UNDERGRADUATE SUBJECTS

Hy. 1. HYDRAULICS. 12 units (3-3-6); first, second or third term. Prerequisite: AM. 1 a, or to be taken at the same time.

Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; hydraulic turbines; centrifugal pumps and other hydraulic equipment.

Text: Hydraulics, Daugherty.

Instructors: Daugherty, Knapp, Gevecker.

Hy. 2. Hydraulics Laboratory. 6 units (0-3-3); second or third term.

Prerequisite: AM. 1 a, b.

Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs; use of Pitot tube; tests of impulse and reaction turbines, centrifugal pumps, and other hydraulic apparatus.

Instructors: Knapp, Ippen.

Hy. 3. HYDRAULICS PROBLEMS. 6 units (0-6-0); first term.

Prerequisite: Hy. 1.

Selected advanced problems in hydraulics such as penstock design, water hammer and surge chamber calculations, hydraulic jump determinations, etc.

Instructor: Knapp.

Hy. 4. HYDRAULIC MACHINERY. 9 units (3-0-6); third term.

Prerequisites: Hy. 1 and 2.

Theory, construction, installation, operation, and characteristics of hydraulic turbines and centrifugal pumps.

Instructor: Knapp.

ADVANCED SUBJECTS

Hy. 100. APPLIED HYDRODYNAMICS. 12 units (3-0-9); second term. Prerequisites: Hy. 1 and 2.

Velocity distribution; turbulence; pipe friction; cavitation; principles of similitude; model studies.

Instructors: Daugherty, Knapp.

Hy. 101. HYDRAULIC MACHINERY. Units to be based on work done; any term.

A study of such machines as the hydraulic turbine and the centrifugal pump and their design to meet specified conditions.

Instructors: Daugherty, Knapp.

Hy. 200. Advanced Work in Hydraulic Engineering.

Special problems in hydraulics will be arranged to meet the needs of students wishing to do advanced work in this field.

DIVISION OF THE GEOLOGICAL SCIENCES GEOLOGY, PALEONTOLOGY, AND GEOPHYSICS

PROFESSORS: JOHN P. BUWALDA, BENO GUTENBERG, CHESTER STOCK ASSOCIATE PROFESSOR: IAN CAMPBELL ASSISTANT PROFESSOR: HORACE J. FRASER INSTRUCTOR: JOHN H. MAXSON

UNDERGRADUATE SUBJECTS

Ge. 1 a. PHYSICAL GEOLOGY. 9 units (3-3-3); first term.

Prerequisites: Ch. 1 a, b, c; Ph. 1 a, b, c.

A consideration of the composition and structure of the Earth and the internal and external processes which modify the crust and the surface. Dynamical and structural geology. Lectures, recitations, laboratory and weekly field trips.

Text: Pirsson and Schuchert's Text-book of Geology, Part I. Instructors: Buwalda, Maxson, Borys, Kemnitzer, Schultz, Uhrig.

Ge. 1 b. ELEMENTARY PALEONTOLOGY. 9 units (4-1-4); third term. Prerequisite: Ge. 1 a.

A discussion of the principles on which the history of life is based. Illustrations of evolution taken from certain groups of animals of which the fossil record is essentially complete. Occasional field trips.

Text: Lull, Organic Evolution.

Instructors: Stock, Wilson.

Ge. 1 c. HISTORICAL GEOLOGY. 9 units (3-0-6); third term.

Prerequisite: Ge. 1 a.

A consideration of the geologic history of the earth, as shown by the changing patterns of land and sea and by the succession of faunas and floras. Conferences, lectures, and occasional field trips.

Text: R. C. Moore, Historical Geology. Instructor: Maxson.

Ge. 3 a, b, c. MINERALOGY. 12 units (3-6-3), each term.

Prerequisites: Ge. 1 a, Ch. 1 a, b, c.

A comprehensive course dealing with the materials of the earth's crust. The first part of the course constitutes an introduction to crystallography; the body of the course is concerned with physical, chemical, and determinative mineralogy, and with the genesis and occurrence and use of minerals; the last part deals especially with mineral aggregates (rocks), their classification, field identification and geologic occurrence. Together with correlated work in Ge. $\tilde{\tau}$ a, b, this portion of the course is designed to give the student a working knowledge of lithology, sufficient for the needs of the field geologist.

Text: Dana's Textbook of Mineralogy, by W. E. Ford, 4th Edition. Instructors: Campbell, Fraser, Kelley, MacLellan.

Ge. 5. OPTICAL MINERALOGY. 10 units (2-6-2), first term.

Prerequisites: Ge. 1, 3,

Study of optical mineralogy and use of the petrographic microscope in the identification of minerals.

Text: Roger and Kerr, Thin Section Mineralogy. Instructors: Anderson, Osborn.

Ge. 6 a, b. PETROGRAPHY. 10 units (2-6-2), second term; 14 units (3-6-5), third term.

Prerequisites: Ge. 3 a, b, c, Ch. 21 a, 23 a.

A systematic study of rocks; the identification of their constituents by application of the polarizing microscope; interpretation of textures; problems of genesis; qualitative and quantitative classifications. Occasional field trips will be arranged.

Text: Grout, Petrography and Petrology.

Instructors: Campbell, Osborn.

Ge. 7 a, b. FIELD GEOLOGY. 10 units (1-8-1), second and third terms. Prerequisites: Ge. 1 a, b, c, 3 a.

An introduction to the principles and methods used in geologic mapping. Field technique in determining rock types and their distribution, and in interpreting geologic relationships and structures. Practical experience in deciphering the geologic history of a region. To these ends a representative Coast Range area is mapped in detail and a report in professional form is prepared on its stratigraphy, structure and history. The field work, selected textbook assignments, and special geologic problems and computations are discussed in weekly class meetings.

Students taking this course are expected to go on the Annual Spring Field Trip described under Ge. 8.

Text: Lahce, Field Geology.

Instructor: Maxson.

Ge. 8. SPRING FIELD TEIP. 1 unit, week between second and third terms.

Brief studies of various localities in the Southwest representative of important geologic provinces. Trips are conducted in successive years to
Owens and Death Valleys where excellent Paleozoic sections are exposed, and Basin Range structure and morphology may be observed; to the Salton Basin and Lower California where the San Andreas fault and the Peninsular Range may be studied; to the San Joaquin Valley and the mountains to the west where important Tertiary formations are exposed and typical Coast Range structure may be seen; and to the Grand Canyon of the Colorado River where a fascinating record of Archean, Algonkian and Paleozoic geologic history may be investigated.

Required of senior and graduate students in the Division of Geological Sciences.

Instructor: Buwalda.

Ge. 9. STRUCTURAL GEOLOGY. 10 units (4-0-6); first term. Prerequisite: Ge. 7 a.

A consideration of the structural features of the Earth's crust; folds, faults, joints, foliation.

Instructor: Buwalda.

Ge. 10. Engineering Geology. 9 units (2-2-5), third term.

Prerequisite: Ge. 1a.

A brief outline of mineralogy, petrology, and structural geology, followed by a discussion of those geological conditions that affect particular engineering operations, such as tunnelling, the building of dams, the retention of water in reservoirs, foundation excavation, harbor work, control of erosion and landslides, materials of construction, etc. Lectures and assigned reading.

The course is planned primarily for civil engineers. Instructor: Buwalda.

Ge. 11 a, b. INVERTEBRATE PALEONTOLOGY. 8 units (1-6-1), first term; 10 units (2-6-2), second term.

Prerequisites: Ge. 1 a, b, c.

Morphology and geologic history of the common groups of fossil invertebrates, with emphasis on progressive changes in structures and their significance in evolution and in adaptive modifications. Laboratory, conferences, lectures, and occasional field trips.

Instructor: Popenoe.

Ge. 12 a, b. VERTEBRATE PALEONTOLOGY. 10 units (2-6-2), second and third terms.

Prerequisite: Ge. 1 b.

Osteology, affinities, and history of the principal groups of fossil mammals and reptiles. History of vertebrate life with special reference to the region of western North America.

Instructor: Stock.

Ge. 14. GEOLOGIC ILLUSTRATION. 10 units (0-10-0), first term.

Freehand sketching of landscape forms and visible geologic structures in the field developing both line and shading technique in representation. Also classroom exercises utilizing various mediums. Training in the drawing of block diagrams illustrating land forms and geologic structure sections in perspective. Problems in projection.

Text: Lobeck, Block Diagrams.

Instructor: Ridgway.

Ge. 21. SENIOR THESIS PROBLEM IN GEOLOGY. Units to bring total load per term to 50.

Prerequisite: Ge. 7 a.

The student investigates a limited geologic problem in the field or laboratory. Individual initiative is developed, principles of research are acquired, and practice gained in technical methods. The student prepares a thesis setting forth the results of the research and their meaning. Last date for acceptance of thesis, May 25.

Instructor: Maxson.

Ge. 22. SENIOR THESIS PROBLEM IN PALEONTOLOGY. 8 units first or third terms, 6 units second term.

Prerequisites: Ge. 11 a, b, or Ge. 12 a, b; may be taken concurrently.

Special investigations in either invertebrate or vertebrate paleontology. Research on a limited problem involving either field relationships of fossil assemblages or consideration in the laboratory of the structural characters and relations of fossil forms. Preparation of a thesis.

Ge. 23. SUMMER FIELD GEOLOGY. 12 units.

Intensive field mapping of a selected area from a centrally located field camp. Determination of the stratigraphy, fossil content, structure, and geologic history. The area chosen will probably lie in the California Coast Ranges in even-numbered years and in the Great Basin in oddnumbered years. As an occasional alternative an expedition will be conducted to localities important in California geology. The interpretations of classical localities afforded in the literature will be studied in the field. The course begins immediately after Commencement (about June 12th). Required at the end of both the Junior and the Senior year for the Bachelor's degree in the Geology and Paleontology course.

Instructors: Buwalda, Maxson.

Ge. 100. GEOLOGY-PALEONTOLOGY CLUB. 1 unit, all terms.

Presentation of papers on research in geological science by the students and staff of the Division of Geological Sciences, and by guest speakers.

Required of all senior and graduate students in the Division.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ge. 183. SEISMOLOGY. 6 units (2-0-4); second term of 1936-1937.

Prerequisites: Ma. 2 a, b; Ph. 2 a, b. c.

Study and conferences on the principles of physical and geological seismology.

Text: Gutenberg, Grundlagen der Erdbebenkunde.

Instructor: Gutenberg.

Ge. 184. LABORATORY STUDIES IN SEISMOLOGY. (0-3-3); first, second or third term.

Prerequisite: Ge. 183 or 203 or 206.

Laboratory practice in the measurement and interpretation of instrumental earthquake records.

Instructor: Gutenberg.

Ge. 186. GEOMORPHOLOGY. 10 units; first term of 1936-1937.

Prerequisite: Ge. 9.

Nature and origin of the physiographic features of the earth. Geologic processes involved in their development. Use of physiography in elucidating the later geologic history of regions.

Instructor: Maxson.

Ge. 187. RESEARCH.

Original investigation, designed to give training in methods of research, to serve as theses for higher degrees, and to yield contributions to scientific knowledge. These may be carried on in the following fields: (m) mineralogy, (n) general areal geology, (o) stratigraphic geology, (p) structural geology, (q) physiography, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) scismology, (v) economic geology, (w) general geophysics, (x) applied geophysics.

Ge. 188. Advanced Study.

Students may register for not to exceed 8 units of advanced study in fields listed under Ge. 187. Occasional conferences; final examination.

Ge. 189 a. PHYSICAL GEOLOGY (SEMINAR). 5 units; first term.

Critical review of literature dealing with some part of the field of structural geology.

Instructor: Buwalda.

Ge. 189 b. PHYSICAL GEOLOGY (SEMINAR). 5 units; third term.

Study and critical discussion of current contributions to geologic knowledge.

Instructor: Buwalda.

Ge. 190 a, b. VERTEBRATE PALEONTOLOGY (SEMINAR). 5 units; second and third terms.

Discussion of progress and results of research in vertebrate paleontology. Critical review of current literature.

Instructor: Stock.

Ge. 191 a, b. INVERTEBRATE PALEONTOLOGY (SEMINAR). 5 units; first and second terms.

Conferences on research in invertebrate paleontology and reviews of literature. Discussions of particular aspects of invertebrate paleontology with special reference to the Pacific Coast.

Instructor: Popenoe.

Ge. 195. ORE DEPOSITS. 10 units (3-0-7); second term.

Prerequisites: Ge. 1, 3, 4, 5, 6, 7.

A study of metalliferous deposits with particular reference to their geological relations and origins. Lectures, recitations, and field trips.

Text: Not prescribed, but either Tarr's Introductory Economic Geology or Emmons' Principles of Economic Geology is suggested, with Lindgren's Mineral Deposits as collateral reading.

(Not given in 1935-1936.)

Ge. 196. Non-METALLIFEROUS DEPOSITS. 10 units (3-0-7); third term. Prerequisites: Ge. 1, 3, 4, 5, 6, 7.

Modes of occurrence, distribution, and origin of the principal nonmetallic mineral products, including mineral fuels, building materials, etc.

Text: Not prescribed, but Ries' Economic Geology or an equivalent text will be found useful.

(Not given in 1935-1936.)

• Ge. 197. ADVANCED ECONOMIC GEOLOGY. 5 units (2-0-3); second and third terms.

Prerequisites: Ge. 195, 196.

A more thorough and comprehensive study of some of the important

mineral deposits of the world than is practicable in courses 195 and 196. Particular attention will be given to deposits in the western United States, Mexico, and Africa.

Instructors: Fraser, Campbell, Anderson.

Ge. 198 a, b. ECONOMIC GEOLOGY (SEMINAR). 5 units; second term. Prerequisites: Ge. 195, 196, or equivalents.

Discussion of current literature and special problems. The seminar work may be varied by occasional lectures.

Instructors: Fraser, Campbell, Anderson. (Not given in 1935-1936.)

Ge. 199. MINERALOGY (SEMINAR). 5 units; first term.

Prerequisite: Ge. 3, 4, 5, 6.

Discussion of current literature and recent advances in this field. Instructor: Fraser.

Ge. 200 a, b. MINERAGRAPHY. 9 units (1-6-2); first and second terms. Prerequisites: Ge. 3, 4, 5, 6, 195.

Investigation of ores and associated minerals by microscopic examination of polished sections, microchemistry, petrography and field studies. Instructor: Fraser.

Ge. 203. Introduction to General Geophysics. 6 units (2-0-4); first term.

Prerequisites: Ma. 2 a, b, Ph. 2 a, b, c.

Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties, temperature; density.

Instructor: Gutenberg.

Ge. 205. APPLIED GEOPHYSICS I. Measurements of gravity, earth magnetism and electricity applied to geological problems and prospecting. 5 units; first term of 1935-1936 and 1937-1938.

Prerequisites: Ph. 2 a, b, c; Ma. 2 a, b.

 $Instructors: \ Soske, \ Peterson.$

Ge. 206. APPLIED GEOPHYSICS II. Methods of seismology applied to geological problems and prospecting. 5 units; second term of 1935-1936 and 1937-1938.

Prerequisites: Ph. 2 a, b, c; Ma. 2 a, b. Instructor: Gutenberg. Ge. 208 a, b. GEOPHYSICS (Seminar). 5 units; first and third terms. Prerequisites: Ge. 183 or 203 or 205 or 206.

Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density; changes in the earth's crust; earthquakes; applied geophysics.

Instructors: Gutenberg, Buwalda.

Ge. 210. ADVANCED PETROLOGY. 8 units; second term.

Prerequisite: Ge. 6 a, b.

A continuation and amplification of Ge. 6 a, b; dealing especially with the metamorphic rocks in 1935-1936, with the sedimentary rocks in 1936-1937.

Texts: Milner, Sedimentary Petrography; Harker, Metamorphism. Instructor: Campbell.

Ge. 211. PETROLOGY (Seminar). 5 units; third term.

Discussion of classic and current literature with consideration of recent advances in the field of petrology. Occasional conferences on research problems are included.

Instructor: Campbell.

Ge. 220. HISTORY OF GEOLOGY. 5 units; second term of 1936-1937.

A study of the development of the geological sciences. The evolution of fundamental theories as influenced by earlier and contemporary geological investigators.

This brief course presents a connected sequence of the development of geological ideas and thereby aids in gaining a perspective of the science.

Lectures, assigned reading, and reports.

Instructor: Maxson.

Ge. 225. GEOLOGY OF THE SOUTHWEST. 10 units (4-0-6); first term of 1936-1937.

An intensive review of the geomorphology, stratigraphy, and structure of the region most accessible from the California Institute, including Arizona, Nevada, and California. Presents an organized concept of the geologic history of the Colorado Plateau Province, the Basin and Range Province, and the Coast Range Province. Lectures, mainly by staff members personally familiar with the regions discussed, and assigned reading.

Instructors: Staff of the Division of the Geological Sciences.

DIVISION OF BIOLOGY

PROFESSORS: THOMAS HUNT MORGAN, HENRY BORSOOK, ALFRED H. STURTE-VANT, FRITS W. WENT

Associate Professor: Ernest G. Anderson

Assistant Professors: Theodosius Dobzhansky, Robert Emerson, Sterling H. Emerson, Hugh M. Huffman, George E. MacGinitie, Cornelis A. G. Wiersma

INSTRUCTORS: GEORGE W. BEADLE, KENNETH V. THIMANN, ALBERT TYLER

For the study of biology, the Institute provides the following opportunities:

An option in biology has been introduced into the four-year undergraduate Course in Science. This option includes those fundamental biological subjects that are an essential preparation for work in any special field of pure or applied biology. This three-year course affords a far more thorough training in the basic sciences of physics, chemistry, and mathematics than students of biology, medicine, or agriculture commonly receive. Special opportunities are also offered for the pursuit of more advanced courses and extended researches leading to the degree of Doctor of Philosophy.

UNDERGRADUATE SUBJECTS

Bi. 1. ELEMENTARY BIOLOGY. 9 units (3-3-3); second term.

An introductory course intended to give the student of general science some information about the fundamental properties of living things.

Instructors: Morgan, Borsook, Beadle.

Bi. 2. GENETICS. 9 units (3-4-2); third term.

An introductory course presenting the fundamentals of genetics in connection with some general biological problems, such as variation and evolution.

Instructor: Dobzhansky.

Bi. 3. GENERAL BOTANY. 14 units (2-9-3), third term. A general survey of the morphology and life histories of plants. Instructor: S. Emerson. Bi. 4. INVERTEBRATE ZOOLOGY. 10 units (2-6-2); third term.

A survey of the main groups of invertebrates (excluding insectssee Bi, 11).

Instructor: MacGinitie.

Bi. 5 a. PLANT PHYSIOLOGY. 10 units (2-6-2); first term. A general study of water relations, growth and tropisms. Instructor: Went.

Bi. 5 b. PLANT PHYSIOLOGY. 10 units (2-6-2); second term. A general study of photosynthesis, respiration, and chemical reactions occurring in plants.

Instructors: R. Emerson and Thimann.

Bi. 6. EMBRYOLOGY. 12 units (2-8-2); second term. A course in descriptive and experimental embryology. Instructor: Tyler.

Bi. 7 a, b. BIOCHEMISTRY. 10 units (2-4-4); first and second terms.

A lecture course on the chemical constitution of living matter; and the chemical changes in animal physiology, with laboratory work illustrating principles and methods in current use.

Instructors: Borsook and Huffman.

Bi. 8. Advanced Genetics. 12 units (3-5-4); third term.

A more advanced course than Bi. 2, dealing especially with mutation, crossing over, and chromosome aberrations.

Instructor: Sturtevant.

Bi. 10. BACTERIOLOGY. 14 units; third term.

The principal reactions carried out by bacteria, and the main groups of micro-organisms responsible for these reactions.

Instructor: Thimann.

Bi. 11. ENTOMOLOGY. 14 units; third term.

A general survey of the structure and life histories of the insects, emphasizing the groups that present favorable material for experimental work.

Instructors: Dobzhansky and Sturtevant.

Bi. 12. HISTOLOGY. 9 units (1-6-2); first term.

A course in technique and in the microscopic structure of animals. Instructor: Tyler. Bi. 13. MAMMALIAN ANATOMY. 5 units (1-2-2); first term. The dissection of a mammal. Instructor: van Harreveld.

Bi. 15. CytoLogy. 14 units; third term.

A study of the cell, with special reference to the chromosomes and to technique.

Instructor: Beadle.

Bi. 16 a, b. ANIMAL PHYSIOLOGY. 10 units (3-2-5); first and second terms.

A survey of comparative and mammalian physiology. Instructors: Wiersma and van Harreveld.

Bi. 17. VERTEBRATE ANATOMY. 10 units; summer.

This course, given at the marine station at Corona del Mar, deals with the comparative anatomy of the vertebrates.

Instructor: MacGinitie.

Bi. 22. RESEARCH. 14 units; third term.

An opportunity will be given to follow special lines of research under direction.

ADVANCED COURSES

Instruction will be given by lectures and seminars; and research will be forwarded by intimate contact between students and instructors in the laboratories. In view of the great expense of modern research along physiological lines, the department will make careful selections of students of exceptional ability and aptitude in order to avoid the formal instruction that large numbers entail.

Bi. 100. GENETICS JOURNAL CLUB. Meets twice monthly for presentation and discussion of current literature and original work.

Instructor: Sturtevant.

Bi. 101. BIOLOGY JOURNAL CLUB. Meets twice monthly for reports on current literature of general biological interest.

Instructor: Morgan.

Bi. 102. PHYSIOLOGY AND BIOCHEMISTRY SEMINAR. A seminar throughout the academic year on special selected topics and on recent advances. Instructors: Huffman and Wiersma,

Bi. 103. PLANT PHYSIOLOGY SEMINAR. Meets twice monthly. Instructor: Went.

Bi. 104. GENETICS SEMINAR. Reports and discussion on special topics. Instructor: Anderson.

Bi. 110. BIOCHEMISTRY. Advanced work, with opportunity for research is offered to graduate students who have completed work in General and Organic Chemistry.

Instructor: Borsook.

Bi. 112. BIOPHYSICS. Photosynthesis, respiration, fermentation, in unicellular organisms. The mechanism of the response to light in various organisms, with a consideration of the light-sensitive system in the human eye.

Instructor: R. Emerson.

Bi. 120. EXPERIMENTAL EMBRYOLOGY. Lectures and seminar work on physiological embryology and related subjects.

Instructor: Tyler.

Bi. 130. BIOLOGICAL PROBLEMS.

A course of lectures and reading, including such general topics as life cycles of protozoa and insects, secondary sexual characters and hormones; parthenogenesis, regeneration and grafting; the nature of biological theories, etc.

Instructor: Morgan.

Bi. 140 a, b. c. PLANT PHYSIOLOGY. 8 units (2-0-6); first, second, and third terms. Reading and discussion of the main problems of plant physiology.

Instructors: Went and Thimann.

Bi. 160. ADVANCED PHYSIOLOGY. A course in the methods of physiology, with special reference to those in nerve and muscle, with opportunity for research.

Instructors: Wiersma, van Harreveld.

Bi. 170. RESEARCH. In special cases, not included in the preceding announcements, students doing advanced work in the department may register under this heading and receive a stated amount of credit.

DIVISION OF THE HUMANITIES

ENGLISH

PROFESSOE: CLINTON K. JUDY
ASSOCIATES: HARDIN CRAIG, FREDERICK M. PADELFORD, LOUIS B. WRIGHT
ASSOCIATE PROFESSOR: GEORGE R. MACMINN
ASSISTANT PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE, ROGER STANTON
INSTRUCTOR: L. WINCHESTER JONES

A course in English composition is prescribed for all students in the Freshman year, and a course in the survey of English literature is prescribed for all students in the Junior year. In the Senior year the students are offered a number of options in English, American, and European literature.

The instruction in composition is intended to give a thorough training in both written and spoken English. The instruction in literature is intended to provide an appreciative acquaintance with the chief works of those authors, past and present, who are most significant in the development of modern civilization, and to foster the habit of self-cultivation in books.

The regular courses in English do not exhaust the attention given at the Institute to the student's use of the language; all writing, in whatever department of study, is subject to correction with regard to English composition.

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination is not confined to specific courses, but covers the general attainments of the students in their humanistic work throughout the first two years.

UNDERGRADUATE SUBJECTS

En. 1 a, b, c. ENGLISH COMPOSITION AND READING. 6 units (3-0-3); first, second and third terms.

This course is designed to give the student a thorough review of the principles of composition, with much practice in writing and speaking, and a broad introduction to good reading. The student is offered every inducement to self-cultivation, and is allowed ample opportunity for the exercise of special talents or the pursuit of special intellectual interests.

The work of the honor section is directed toward the stimulation of intellectual initiative. The members of the section are held to high standards of excellence in writing and speaking, and are expected to undertake a considerable amount of cultural reading.

Texts: Better Themes, Marks; These United States, Jones, Huse, and Eagleson; College Readings in the Modern Short Story, MacMinn and Eagleson; Webster's Collegiate Dictionary.

Instructors: Eagleson, Huse, Jones, MacMinn, Stanton.

En. 7 a, b, c. SURVEY OF ENGLISH LITERATURE. 8 units (3-0-5); first, second and third terms.

Prerequisite: En. 1 a, b, c.

A selective study of English literature from the 16th Century to the 20th, focused on representative works by seven major authors: in the first term, Shakespeare; in the second, Swift, Pope, and Wordsworth; in the third, Carlyle, Browning, and Masefield.

Instructors: Eagleson, Huse, Jones, Judy, MacMinn, Stanton.

En. 8. CONTEMPORARY ENGLISH AND EUROPEAN LITERATURE. 9 units (3-0-6); first, second or third term.

Prerequisite: En. 7 a, b, c.

A continuation of the survey of English literature to cover the period from 1890 to the present, with some extension into Continental literature. Wide reading is required.

Text: The Georgian Scene, Frank Swinnerton.

Instructors: Eagleson, Judy.

En. 9. CONTEMPORARY AMERICAN LITERATURE. 9 units (3-0-6); first or second term.

Prerequisite: En. 7 a, b, c.

A survey of the literature of the United States during the past halfcentury, with emphasis upon the chief writers of the present time. Special attention is given to the reflection of national characteristics in the novel, the short story, drama, and poetry.

Text: American Poetry and Prose, Part II, Foerster.

Instructor: MacMinn.

En. 10. MODERN DRAMA. 9 units (3-0-6); first, second or third term. Prerequisite: En. 7 a, b, c.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production. Wide reading of plays is required.

Text: Twentieth Century Plays, Chandler and Cordell. Instructors: Huse, Stanton.

En. 11. LITERATURE OF THE BIBLE. 9 units (3-0-6); third term. Prerequisite: En. 7 a, b, c.

A study of the Old and New Testaments, exclusively from the point of view of literary interest. Special attention is given to the history of the English Bible. Opportunity is offered for reading modern literature based on Biblical subjects.

Text: The Bible (Authorized Version).

Instructor: MacMinn.

En. 12 a, b, c. DEBATING. 4 units (2-0-2).

Elective, with the approval of the Registration Committee, for upper classmen in the first and second terms. Study of the principles of argumentation; systematic practice in debating; preparation for intercollegiate debates.

Elective, with the approval of the Freshman Registration Committee, for Freshmen, 2 units (1-0-1) in the second term, and 4 units (2-0-2)in the third term. Lectures on the principles of formal logic and the theory of argumentation and debate.

Instructor: Untereiner.

En. 13 a, b, c. READING IN ENGLISH AND HISTORY. Units to be determined for the individual by the Department.

Elective, with the approval of the Registration Committee, in any term.

Collateral reading in literature and related subjects, done in connection with regular courses in English and History, or independently of any course, but under the direction of members of the Department.

En. 14. SPECIAL COMPOSITION. 2 units (1-0-1); any term.

This course may be prescribed for any student whose work in composition, general or technical, is unsatisfactory. En. 15 a, b, c. JOURNALISM. 3 units (1-0-2).

Elective, with the approval of the Registration Committee.

A study of the principles and practice of newspaper writing, editing, and publishing, especially as applied to student publications at the Institute.

Instructor: MacMinn.

En. 16. Spelling. No credit.

This course may be prescribed for any student whose spelling is unsatisfactory.

En. 20. SUMMER READING. Maximum, 16 credits.

Credits are allowed to the maximum number of 16 for vacation reading from a selected list of books in various subjects, and written report thereon.

FIFTH-YEAR AND ADVANCED SUBJECTS

En. 100. LITERATURE. 9 units; first, second and third terms.

A study of some selected period, or type, or author, or group of authors in American, English or European literature, with an introduction to the methods of research and criticism applicable thereto.

Instructors: Craig, Eagleson, Judy, Padelford, Wright.

LANGUAGES

PROFESSOR: JOHN R. MACARTHUR

The courses in modern languages are arranged primarily to meet the needs of scientific students who find it necessary to read books, treatises, and articles in French, German, and Italian. In the study of these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English. An elective course in Greek is offered to students interested in that language.

UNDERGRADUATE SUBJECTS

L. I a, b. ELEMENTARY FRENCH. 10 units (4-0-6); second and third terms.

A course in grammar, pronunciation, and reading that will provide the student with a vocabulary and with a knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency in this subject. Students who have had French in the secondary school should not register for these courses without consulting the Professor of Languages.

Texts: An Introduction to the study of French, Bond; Adventures par la Lecture, Bovee.

Instructors: Macarthur and Overhage.

L. 11. ELEMENTARY ITALIAN. 9 units (3-0-6); one term, as required. A course designed to give the student who has already some acquaintance with Latin or with another Romance language sufficient knowledge of the forms and vocabulary of Italian to enable him to read scientific Italian, especially in the field of Mathematics.

Texts: Elementary Italian, Marinoni and Passarelli; Capocelli, L'Italia nel Passato e nel Presente.

Instructor: Macarthur.

L. 32 a, b, c. ELEMENTARY GERMAN. 10 units (4-0-6); first, second and third terms.

This subject is presented in the same manner as the Elementary French. Students who have had German in the secondary school or junior college should not register for these courses without consulting the Professor of Languages.

Texts: First German Course for Science Students, Fiedler and Sandbach; Technical and Scientific German, Greenfield.

Instructors: Macarthur and Overhage.

L. 35 a, b, c. SCIENTIFIC GERMAN. 10 units (4-0-6); first, second and third terms.

Prerequisite: L. 32 a, b, c, or one year of college German.

This is a continuation of L. 32 a, b, c, with special emphasis on the reading of scientific literature.

Text: Aus der Werkstatt grosser Forscher, Danneman.

Instructors: Macarthur and Overhage.

L. 39 a, b, c. READING IN FRENCH, ITALIAN, OR GERMAN. Units to be determined for the individual by the department. Elective, with the approval of the Registration Committee, in any term.

Reading in scientific or literary French, Italian, or German, done under direction of the department.

L. 40. GERMAN LITERATURE. 9 units (3-0-6), third term.

Prerequisites: L. 32 a, b, c; L. 35 a.

The reading of selected German classics, poetry and drama, accompanied by lectures on the development of German literature. Elective and offered only to students whose work in the prerequisites has been above average.

Text: German Literature, Thomas.

Instructor: Macarthur.

(Not offered in 1936.)

L. 51 a, b, c. GREEK. 6 units (3-0-3).

This is a course in the elements of the classical Greek language. Special reference is made to scientific nomenclature. Outside reading upon topics drawn from Greek literature, art, philosophy, and science is reported on in term papers. The course is elective, and will be offered only if six or more persons request it and agree to take it throughout the year.

Texts: Alpha, Frost; Xenophon's Anabasis; The Study of Greek Words in English, Including Scientific Terms, Hoffman.

Instructor: Macarthur.

HISTORY AND GOVERNMENT

PROFESSORS: JOHN R. MACARTHUR, WILLIAM B. MUNRO Associates: Merle N. Curti, Godfrey Davies Assistant Professors: Philip S. Fogg, Ray E. Untereiner

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination does not cover specific courses, but the general attainments of the students in their systematic work throughout the first two years.

UNDERGRADUATE SUBJECTS

H. 1 a, b, c. ANCIENT AND MEDIEVAL HISTORY. 5 units (3-0-2); first, second and third terms.

Lectures and discussions upon the early civilizations out of which modern Europe developed, and upon the institutions of the Middle Ages. The students are referred to original sources in the library. In connection with this course, Freshmen are expected to attend a performance of the classical play presented in the fall term, and to make one visit to the Huntington Collections.

Texts: Ancient Times, Breasted (Revised Edition); Munro and Sontag, The Middle Ages.

Instructors: Eagleson, Huse, Jones, Judy, Macarthur, MacMinn, Stanton.

H. 2 a, b, c. MODERN EUROPEAN HISTORY. 6 units (2-0-4); first, second and third terms.

Prerequisite: H. 1 a, b, c.

The general political and social history of Europe from 1500 to 1935, presented as the background and development of movements underlying present conditions.

Instructors: Munro, Untereiner.

H. 5 a, b. CURRENT TOPICS. 2 units (1-0-1); first and second terms. This course is given collaterally with senior humanities electives, and is articulated with a selected weekly journal of general information and opinion.

Instructor: Fogg.

H. 10. THE CONSTITUTION OF THE UNITED STATES. 2 units (1-0-1); third term.

A study of the principles and provisions of the national constitution in the light of present-day interpretation by the courts. Required of all seniors.

Instructor: Munro.

FIFTH-YEAR AND ADVANCED SUBJECTS

H. 100. SEMINAE IN AMERICAN HISTORY AND GOVERNMENT. 9 units (1-0-8); first, second and third terms.

Open only to fifth-year students and seniors who have attained honor grades.

First term: English History in the Nineteenth Century.

Instructor: Davies.

Second term: The Social Ideas of American Scientists and Inventors. Instructor: Curti.

Third term: American Government.

Instructor: Munro.

ECONOMICS

PROFESSOR: GRAHAM A. LAING ASSOCIATE PROFESSOR: HORACE N. GILBERT ASSISTANT PROFESSORS: PHILIP S. FOGG, RAY E. UNTEREINER

The subjects in this group have the twofold purpose of giving the student an insight into fundamental economic principles, and of acquainting 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.

UNDERGRADUATE SUBJECTS

Ec. 2. GENERAL ECONOMICS AND ECONOMIC PROBLEMS. 10 units (4-0-6), second or third term.

The purpose of this course is to describe in as great detail as possible the economic life of the community. It includes a study of production, distribution, and exchange of goods, the nature of money and credit, the development of economic institutions, and an analysis of a number of pressing economic problems. The course is given in the second and again in the third term.

Instructors: Laing (lectures), Gilbert, Untereiner, Fogg.

Ec. 5 a, b. GENERAL ECONOMICS. 6 units (3-0-3) second term, and (2-0-4) third term. Same material as in Ec. 2, but in more detail.

Instructors: Laing (lectures), Untereiner.

Ec. 17. Accounting. 9 units (3-0-6); first, second or third term. Open only to engineering students in their Junior year.

This is a course in the interpretation of the financial statements with which engineering students who enter business will come in contact. A description of bookkeeping methods is presented, but not in sufficient detail to enable the average student to keep a set of business books. Emphasis is placed upon the study of actual business problems involving the executive interpretation of accounting reports. A liberal amount of descriptive material regarding business activities accompanies the instruction.

Text: Accounting, Porter and Fiske. Instructor: Fogg. Ec. 18. INDUSTRIAL ACCOUNTING. 6 units (2-0-4), second term. Prerequisite: Ec. 17.

Open only to third, fourth, and fifth year engineering students. The course covers the essential principles of cost accounting as applied to industrial enterprises. The theoretical background of cost accumulation and distribution is supplemented by case studies of actual industrial accounting experience.

Text: Industrial Accounting, Saunders. Instructor: Fogg.

Ec. 20. FINANCIAL ORGANIZATION. 8 units (3-0-5); first term. Prerequisites: Ec. 2 or 5.

A general study of the financial organization of society. The course includes a study of the following topics: Principles of money; nature and functions of credit; the varieties of credit instruments; the marketing of low and high grade securities; the functions of the corporation and the stock exchange as capital-raising devices; the development of the banking system and the general principles of banking, including studies of commercial banking, the national banking system, and the Federal Reserve system.

Instructor: Laing.

Ec. 25. BUSINESS LAW. 6 units (3-0-3); first term.

The principles of law as applied to business affairs; a study of the law governing contracts, negotiable instruments, agency, partnership, corporations, and employer's liability.

Instructor: Untereiner.

Ec. 34. CORPORATION FINANCE. 8 units (2-0-6); first term.

Corporation promotion; the issue and payment of securities; underwriting; the sale of speculative securities. Discussion of the principles of capitalization, the management of corporate income, and the relation of dividend to income. Financial problems of expansion, combination, and reconstruction of corporations.

Instructor: Laing.

Ec. 45 a, b. SEMINAR IN SOCIAL AND ECONOMIC ORGANIZATION. 4 units (2-0-2); second and third terms.

This course consists in weekly lectures and discussions of the development of economic and social organization from a broad standpoint, and includes consideration of such subjects as primitive economic and political groupings and methods, development of gild and feudal systems, evolution of the competitive and quasi-competitive systems in economic life and democratic organization in political life. A considerable amount of outside reading is expected from each student. The class meets once a week for two hours, the first being devoted to lecture and the second to discussion of the problems treated in the lecture. The number of students is limited and the seminar is open to juniors and seniors. The seminar meets on Thursday evenings at the home of Professor Laing.

Instructor: Laing.

FIFTH YEAR AND ADVANCED SUBJECTS

Ec. 100 a, b, c. BUSINESS ECONOMICS. 12 units (4-0-8); first, second, and third terms. Open to graduate students.

This course endeavors to bridge the gap between engineering and business. It is intended for students in applied science and technology who wish to use their technical training as an approach to the administrative side of business and industry.

The course includes, in brief (a) a description of business and industry, and (b) a consideration of principles of business economics which are relevant to the fields of interest of engineers and applied scientists. The principal subjects treated are (1) business organization, (2) industrial promotion and finance, (3) factory problems, and (4) the marketing of industrial goods. An introduction is given to industrial statistics and accounting. Students are made familiar with the operations of the Federal Reserve system and with various other significant subjects in business economics. Several industries are studied in detail as to the nature of their particular economic problems and as to the actual companies operating in them. The case method of instruction developed by the Harvard Graduate Business School is employed to a considerable extent throughout the course.

Texts: Gilbert and Gragg, Introduction to Business; Slichter, Modern Economic Society.

Instructor: Gilbert.

Ec. 106 a, b, c. BUSINESS ECONOMICS SEMINAR. Units to be arranged; first, second, and third terms. Open to graduate students.

Special studies of current economic problems are presented by the instructor, after which an open discussion is held. Emphasis is placed on the materials of economic science, i.e., statistics of production, consumption, prices, banking and finance, etc. These quantitative studies are accompanied, where advisable, by reference to economic doctrine.

Instructor: Gilbert.

PHILOSOPHY, ETHICS AND SOCIOLOGY

PROFESSORS: THEODORE G. SOARES, GRAHAM A. LAING

UNDERGRADUATE SUBJECTS

Pl. 1. INTRODUCTION TO PHILOSOPHY. 9 units (3-0-6); first and second terms.

An endeavor to see how the most fundamental questions have been answered by typical thinkers in the past, and how the modern student may arrive at a philosophy.

Texts: First term: Hocking, Types of Philosophy; second term: Patrick, Introduction to Philosophy.

Instructor: Soares.

Pl. 4. ETHICS. 9 units (3-0-6); third term.

The fundamental ethical concepts and theories that have emerged in the process of human thought. The major social problems of modern life.

Texts: Wheelwright, A Critical Introduction to Ethics; Clark and Smith, Readings in Ethics.

Instructor: Soares.

Pl. 5. Sociology. 9 units (3-0-6); first term.

The genesis and evolution of human society. The influence of economic, religious and social forces. The nature of social control and the analysis of mores, morals and legal codes. The development of social institutions and the nature of change in these institutions.

The class is conducted as a discussion group.

Text: Fairchild, General Sociology.

Instructor: Laing.

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl. 100. A STUDY OF SOME ASPECTS OF PHILOSOPHICAL, ETHICAL OB SOCIAL DEVELOPMENT. 9 units; first, second and third terms. Instructor: Soares.

DIVISION OF PHYSICAL EDUCATION

PHYSICAL DIRECTOR: WILLIAM L. STANTON ASSISTANT DIRECTOR AND MANAGER OF ATHLETICS: HAROLD Z. MUSSELMAN CONSULTING PHYSICIAN: DR. E. D. KREMERS PHYSICIAN TO ATHLETES: DR. FLOYD L. HANES

PE. 1, 2, 3, 4. PHYSICAL EDUCATION. 3 units; first, second and third terms.

All students during all four undergraduate years are required to participate either in the intramural or intercollegiate sports on which the physical education program is based. The intramural sports comprise competition between student houses, classes and clubs, in all sports, including football, cross-country running, track and field events, baseball, basketball, swimming, boxing, wrestling, tennis, handball, etc., and is required of all students not taking part in intercollegiate sports. Representative freshmen and varsity teams in the major sports are developed and trained by experienced coaches. Fair-spirited and clean-cut athletic competition is encouraged for its social and physical values, and as a foundation for genuine college spirit. During the freshman and sophomore years, all students are given physical strength and skill tests in the first and third terms. These tests are used as a basis of comparison with other men of the same weight and height. Corrective or special exercises are prescribed throughout the four years for those who cannot compete in intramural or intercollegiate sports.

Degrees Conferred, June 7, 1935

DOCTOR OF PHILOSOPHY

- EDWARD DAY ALCOCK, A.B., University of California at Los Angeles; M.S., California Institute
- LUCAS AVERY ALDEN, B.S., California Institute
- VICTOR HUGO BENIOFF, B.A., Pomona College
- CHARLES MELVIN BLAIR, B.A. and M.A., Rice Institute
- LYMAN GAYLORD BONNER, B.A., University of Utah
- SAMUEL J. BROADWELL, B.S., Throop College of Technology; M.S., University of Chicago
- VINTON AUSTIN BROWN, B.S. and M.S., University of Arizona
- JAMES LEON CARRICO, B.A. and B.S., North Texas State Teachers College; M.A., University of Texas
- CHARLES DUBOIS CORYELL, B.S., California Institute
- MAURICE DONNELLY, E.M., Colorado School of Mines; M.S., California Institute
- FREDERICK JUNIOR EWING, B.S., California Institute
- PAUL FRANK GENACHTE, Engineer in Electrical and Mechanical Engineering, Brussels University; M.S.E.E., Massachusetts Institute of Technology
- CARTER HOLT GREGORY, B.S., California Institute
- JESSE EDWARD HOBSON, B.S.E.E. and M.S.E.E., Purdue University
- ROBERT BYRON JACOBS, B.S., California Institute
- JOSEF JEROME JOHNSON, B.S., California Institute; M.S., Ohio Wesleyan University
- JAMES EVERETT IMPP, B.S. and M.S., California Institute
- WILLIAM VIRGIL MEDLIN, B.S., University of California
- Roscoe Harlan Mills, B.S., Pomona College
- SETH HENRY NEDDERMEYER, A.B., Stanford University
- RAYMOND ALFRED PETERSON, B.S., California Institute
- ALBERT ROBERTS POOLE, B.A. and M.A., University of British Columbia
- ARTHUR NICOLAS PRATER, A.B., University of California at Los Angeles; M.S., California Institute
- RUSSELL WATSON RATT, B.S. and M.S., California Institute
- ALFRED ROMER, B.A., Williams College
- JOSHUA LAWRENCE SOSKE, G.E., Colorado School of Mines; M.S., California Institute
- BERNARD BENNETT WATSON, A.B., Temple University
- MERIT PENNIMAN WHITE, A.B. and C.E., Dartmouth College; M.S., California Institute
- CHESTER EUGENE WILSON, B.S. and M.S., California Institute
- HALLEY WOLFF, B.S. and M.S., California Institute

MASTER OF SCIENCE IN ENGINEERING

ELECTRICAL ENGINEERING

EDWARD BUSHNELL DOLL, B.S., California Institute GEORGE GRIMM, JR., B.S., University of Kentucky HAROLD THOMAS HOLTOM, B.S., California Institute RAYMOND EDWARD KIDD, B.S., California Institute PAUL HOYT LEDYARD, B.S., California Institute GILBERT DONALD MCCANN, B.S., California Institute MORTON ESTES MOORE, B.S., California Institute LOUIS TELEMACUS RADER, B.A.SC., University of British Columbia JACK MOODY ROEHM, B.E., Tulane University LOUIS PERRY SEXTON, B.S., California Institute

MECHANICAL ENGINEERING

MILFORD CARLSON CHILDERS, B.S., California Institute

FRANCIS HETTINGER CLAUSER, B.S., California Institute

MILTON URE CLAUSER, B.S., California Institute

PHILIP ABBEY COLMAN, B.S., Stanford University

LEWIS FORT ETTER, B.S., California Institute

ERNEST RUSSELL HOWARD, B.S., California Institute

WALTER LAVERN HOWLAND, B.S., California Institute

WILLIAM WHITTEN JENNEY, B.S., University of Michigan

EDWARD LUCAS KELLS, Bachelor Mechanical Engineering, University of Minnesota

FRANK JOSEPH MALINA, B.S., A. and M. College of Texas

VICTOR JOHN MARTIN, B.S., University of Southern California

HAROLD FRANK RICHARDS, B.S., California Institute

CIVIL ENGINEERING

GLENN CHEW CHAN, B.S., University of California at Los Angeles ARTHUR THOMAS IPPEN, Diplom-Ingenieur, Technische Hochschule, Aachen, Germany

PAUL LOUIS KARTZKE, B.S., California Institute

DARRELL HAYES SLUDER, B.S., California Institute

WALTER SCHOLTZ, B.S., California Institute.

AERONAUTICAL ENGINEERING

HANS MARTIN ANTZ, Diplom-Ingenieur, Technische Hochschule, Darmstadt, Germany

WALLACE MORRIS BEAKLEY, Lieut., U.S.N., United States Naval Academy

KANAME KITUSDA, B.S., Tri-State College; M.S., California Institute

HOWARD MONROF McCov, 2nd Lieut., A.C.U.S.A., United States Military Academy

WARREN SHERMAN PARR, Lieut., U.S.N., United States Naval Academy

JAMES SARGENT RUSSELL, Lieut. (j.g.) U.S.N., United States Naval Academy

ROLAND JAMES WHITE, B.S., University of California; M.S., California Institute

CARLOS CLAUDE WOOD, A.B., College of the Pacific; M.S., California Institute

METEOROLOGY

ROBERT DAWSON FLETCHER, B.S. and M.S., California Institute

PATRICK JOHN D. HARNEY, B.S., Clarkson College of Technology

FUN-CHANG HUANG, B.S., National Southeastern University of Nanking HSIA-CHIEN HUANG, B.S., National Southeastern University of Nanking

ROBERT MOFFATT LOSEY, 1st Lieut., A.C.U.S.A., United States Military

- Academy
- ELMO STEWART MATTHEWS, 1st Lieut., Sig.C.U.S.A., United States Military Academy

DON MCNEAL, Capt. Sig.C.U.S.A., B.S., Ohio State University

HERMAN GUSTAVE PORTMAN, JR., B.S.E. (AE.E) University of Michigan DONALD H. RICKETTS, B.S., University of Utah

- RICHARD ERVINE SLAUGHTER, B.S. in M.E., Southern Methodist University; M.S., California Institute
- KENNETH A. WILLARD, B.S., Northwestern University; M.S., California Institute

LOUVAN ELBERT WOOD, B.Sc., Alma College

MASTER OF SCIENCE IN SCIENCE

PHYSICS

LOREN TOMPKINS CLARK, A.B., University of Southern California

ROBERT ALEXANDER DIETRICH, B.S., California Institute

SEIBERT QUIMBY DUNTLEY, B.S., Massachusetts Institute of Technology ROBERT ADRIAN HOWARD, B.S., California Institute

Oscar BRANCHE JACKSON, B.S., Texas Christian University

FITTEN LAMAR MCMILLIN, B.A., Mississippi College; B.S., Mississippi

State College

ISRAEL ZAKA SLAWSKY, B.S., Rensselaer Polytechnic Institute MILTON SLAWSKY, B.S., Rensselaer Polytechnic Institute

JAMES HAROLD WAYLAND, B.S., University of Idaho

MATHEMATICS

VICTOR ELCONIN, B.S., California Institute

CHEMISTRY

SIEGFRIED THEODORE GROSS, A.B., Colorado College NELSON PERRY NIES, B.S., California Institute NORWOOD LEE SIMMONS, JR., B.S., University of North Carolina

CHEMICAL ENGINEERING

HARRISON STOUT BACKUS, B.S., California Institute Edward Austen Bertram, B.S., University of Illinois

GEOLOGY AND PALEONTOLOGY

YGNACIO BONILLAS, III, B.S., California Institute JACK FINLAY JUDSON, B.S., California Institute ROBERT PHILLIP SHARP, B.S., California Institute

BACHELOR OF SCIENCE

Science

JOSEPH ALBERT ASHWORTH +LAWRENCE WILLIAM H. BALDWIN LEON SANGAMON BECKER ALAN BEERBOWER WARD WILSON BEMAN LEWIS BLAKELY BROWDER *+HORACE WILLARD DAVENPORT JAMES ALLMAN DAVIES, II CHARLES ALEXANDER DAWSON, JR. *THOMAS JAY DEAHL ALBERT ORNO DEKKER +ROBERT HENRY DOURSON **†EUGENE LEROY EDWARDS** CHARLES HALSEY ELMENDORF, III ARTHUR EDWARD ENGELDER HARRY DE ESTES MILTON HARRISON EVANS *CLIFFORD SYMES GARNER ADRIAN HUGO GORDON *EMERSON WARD GREEN RALPH E. HOMANN, JR. BYRON NOLL INMAN *+BICHARD HENRY JAHNS ROBERT GARDNER JONES WILLIAM FORREST KEYES, JR.

PAUL WILLIAM KILPATRICK *FRED CHARLES KING. JR. ROBERT ORVILLE LA RUE DAVID JOHN LEHMICKE *+HENRI ARTHUR LEVY +CHESTER WILLIAM LINDSAY *WILLIAM BURDETTE MCLEAN *RICHARD BURTON NELSON NELSON PERRY NIES CHARLES WASHINGTON PATRICK LEONARD SEARLES PATTERSON *KENNETH SANBORN PITZER EDWARD HENRY REVNOLDS *HERBERT SPENCER RIBNER JOHN BUDOLPH BOSSUM IVAN VICTOR SCHERB +HAROLD SCITILLER DICKSON MARSHALL SHEPPARD JAMES BATES STODDARD HENRY WILLIAM STOLL [†]LAURENCE JUSTINIAN STUPPY JAV CAMBURN TAYLOR GEORGE JARVIS TOOBY *Robert Collett Warner

Engineering

FREDERICK HAMILTON ALLARDT HORACE WHITE BAKER DONALD NEWTON CHAMBERLAIN CLYDE CUTHBERTSON CHIVENS †WILLIAM GORDON COX LIND BURNETT DAVENPORT †CHESTER ARTHUR DAVIS NORMAN BRANSON DEWEES OLIVER CHURCHILL DUNBAR JACKSON EDWARDS GUSTAVE EHRENBERG, JR. GORDON RICHARDSON EWING GREER WILSON FERVER ROBERT GEORGE FUSSELL FRANCIS ROWELL GAY JOHN ROSWELL GELZER CHARLES JAMES GIBES HOWARD PHILIP GLUCKMAN EUCENE GRAHAM, JR. BRUCE BENSON GRAVITT

*Graduated with honor in accordance with a vote of the Faculty. †Awarded the Honor Key by the Associated Student Body for participation in student activities.

*+THOMAS WILLIAM GRIFFITHS **+ROBERT JOHN HALLANGER** JAMES JOSEPH HALLORAN JOHN BALL HIGLEY *JAMES HENRY JENNISON *†WALLACE J. S. JOHNSON ROBERT PARRY JONES PAUL ALTON JOSEPH NATHAN KARP MILO CLEMENT KETCHUM HARRY MONTFORD KOONS +ROBERT LINCOLN KRAMER ELMER LOUIS LEPPERT. JR. FRED VERN MALONEY ROBERT ALEXANDER MCRAE FRANZ NELSON MERRALLS DANIEL HARRISON MILLER **†EUGENE CLAIR MILLER** WILLIAM CARTER MOSTELLER TANEMI OBATAKE FREDERICK PEHOUSHEK PERRY PAUL POLENTZ

†WARREN THOMAS POTTER, JR. ALBERT ALLEN RAY JOHN RITTER DAGOBERTO RIVAS JACK WILLIAM SCHWARTZ CLAUDE TRICK SCOTT *ALLAN ROMIG SCOVILLE ROBERT KLENSCH SEIDEL SANDER DAVID SHEFF ALFRED LEON SLATER *GALE MORELAND SMITH JAMES NORMAN SMITH ROBERT M. STANLEY +JOHN CHESTER STICK, JR. +CHARLES FRANKLIN THOMAS CHARLES SUMNER THOMPSON, JR. MABRY VAN REED +DONALD CHARLES WEBSTER VICTOR WILMER WILLITS, JR. HERBERT LEE WOODBURY BRADLEY HOBART YOUNG

*Graduated with honor in accordance with a vote of the Faculty. $^{\dagger}Awarded$ the Honor Key by the Associated Student Body for participation in student activities.

Honors, 1935

SENIOR SCHOLARS:

WILLIAM EDWARD CAMPBELL, JR., CLARENCE FRANCIS GOODHEART, BRUCE LATHAN HICKS, HARRY W. LEW, EUCLID WATTS

JUNIOR SCHOLARS:

IRVING LOUIS ASHKÈNAS DON CHARLES DEVAULT RICHARD WOLFORD DODSON JOHN S. EDWARDS, JR. CHARLES FREDRICK GATES LEVAN GRIFFIS THOMAS SINCLAIR HARPER ROBERT CALDWELL JONES DONALD CHARLES NELLIS ROBERT HORNER OLDS DAVID PRESSMAN EDWARD THOMAS PRICE RICHARD ROSENCRANZ, JR. THOMAS NEWTON SHAW

DRAKE SENIOR SCHOLAR: ROBERT LEE JANES

DRAKE JUNIOR SCHOLAR: WILLARD FARNHAM

SOPHOMORE SCHOLARS:

DAVID KENT BEAVON WILLIAM THOMAS CARDWELL HERBERT BAILEY ELLIS ORAN AVERY GRAYBEAL, JR. CLYDE WINGER HARRIS HARRISON MORTON LAVENDER CLAY WARDEN LEWIS FRED EATON LLEWELLYN FRANKLIN HOMER PAGE, JR. JOHN E. PARKER DAVID MARX SHERWOOD RICHARD NORMAN WIMPRESS HOMER JESSE WOOD

BLACKER FRESHMAN SCHOLARS:

DONALD ANDREW CALDWELL, San Diego High School CHARLES FREDERICK CARSTARPHEN, East High School, Denver, Colorado WALLACE FREDERICK DAVIS, Menlo School HAROLD VIVIAN HANCE, Lincoln High School, Los Angeles RODERICK M. MCCLUNG, Winslow High School, Winslow, Arizona EDMUND JOY PINNEY, Lincoln High School, Seattle, Washington BERT VICTOR ROUDEBUSH, Herbert Hoover High School, Glendale PAUL LOUIS SMITH, Pasadena Junior College PAUL N. A. VEENHUYZEN, Alhambra High School BEVERLY HILLS FRESHMAN SCHOLARS:

HENRY PATRICK CAULFIELD, JR., Hollywood High School ALBERT PENNINGTON GREEN, Hollywood High School DAVID HOLCOMB SCOTT, Fairfax High School, Los Angeles

INSTITUTE FRESHMAN SCHOLARS:

GRICE AXTMAN, South Pasadena High School
RICHARD HAWLEY BISHOP, Milwaukee Country Day School, Milwaukee, Wisconsin
PHILIP S. DEVIRIAN, Muir High School, Pasadena
NORMAN PAUL GELDSON, Lincoln High School, Los Angeles
FREDERICK C. HOFF, Elgin High School, Elgin, Minnesota
KENNETH GORDON MACLEISCH, Santa Barbara High School
ARNOLD LAWRENCE ROGERS, Wilson High School, Long Beach
PHILIP ERNEST SMITH, Santa Ana High School

American Chemical Society Scholar:

WILLIAM EMIL BROWN, George Washington High School, Los Angeles

CONGER PEACE PRIZE:

WALLACE J. S. JOHNSON, HOWARD PHILIP GLUCKMAN

246

Graduate Students

Abbreviations: Eng., Engineering; Sci., Science; EE, Electrical Engineering; ME, Mechanical Engineering; CE, Civil Engineering; Ch, Chemistry; Ch E, Chem-ical Engineering; Ph, Physics; Ge, Geology; Ma, Mathematics; AE, Aeronautical Engineering; Bi, Biology; Ay, Astronomy; My, Meteorology; A Ch, Applied Chem-istry; A Ph, Applied Physics. (†) following a student's name indicates that he has been admitted to candidacy for the degree of Doctor of Philosophy.

	Major	
NAME	SUBJEC:	f Home Address
ALEXANDER, CHARLES KIRKWOOD (†)	\mathbf{Ph}	Oberlin, Ohio
ALLARDT, FREDERICK HAMILTON	\mathbf{AE}	Fresno
Ambrose, William Bryant	My	Beaumont
B.S., University of Texas, 1923 ANDERSON, LEROY HAGEN	$\mathbf{C}\mathbf{h}$	Conrad, Montana
B.S., Montana State College, 1927	Ch	Glendale
B.S., California Institute, 1932	Ma	Lineste Nobrogleo
A.B., University of Nebraska, 1933	ma	Lincolli, Nebraska
ARTHUR, WILLIAM THOMAS University of Omaha, 1928-32	AE	Omaha, Nebraska
ATSUMI, JOHN SHOICHI	AE	Stockton MSE University of Michigan
1935 BAUER BAIRT D	AE.	Laurence Kansas
BS University of Htah 1927 MS	Univer	sity of Kansas 1931
BAMBERGER, SIDNEY FRANCIS	CE	Venice
BASSETT, HAROLD HUNTLEY	My	Washington, D. C.
BEACH, JOHN YOUNGS (†)	Ch	Berkeley
B.S., University of California, 1933 BECKER, ROBERT ADOLPH	\mathbf{Ph}	Tacoma, Washington
B.S., College of Puget Sound, 1935 BEESON, CARROL MENEFEE	$\mathbf{C}\mathbf{h}$	Los Angeles
A.B., University of California at Los BENDER, DAVID FULMER (+)	Angeles, Ph	1935 Spokane Washington
BS California Institute 1933: MS	1034	Spokane, washington
BIRKINSHAW, ERNEST ARTHUR	Ph	Rapid City, Manitoba, Canada
BOCHE, ROBERT DEVORE	Bi	Seattle, Washington
B.S., California Institute, 1934 Bolger, Henry Joseph	\mathbf{Ph}	Notre Dame, Indiana
A.B., University of Notre Dame, 1924 1929	; M.A.,	, Catholic University of America,
BOLLAY, EUGENE	$\mathbf{M}\mathbf{y}$	Evanston, Illinois
Bollay, William (†)	AE	Evanston, Illinois
B.S., Northwestern University, 1933; BOLLMAN, VERNON LEROY (†)	м.S., C Ph	ainornia Institute, 1934 Pasadena
B.S., University of Nebraska, 1931; M BOISTER, CALVIN MATHEWS	A.S., 193 AE	33 Bayenna, Ohio
United States Naval Academy 1916-21	· M.S	Massachusetts Institute of Tech-
nology, 1923	,,	Augustinette Institute of Teen

-

MAJOR SUBJECT NAME Home Address Minneapolis, Minnesota BORYS, EDMUND Ge B.A., University of Minnesota, 1932 BOWEN, WILLIAM HAROLD AE Pasadena B.S., University of California, 1928; M.S., California Institute, 1932 BRICE, RICHARD THEOBOLD (†) Ph Pasadena B.S., Emory University, 1931; M.S., 1932 BRUBAKER, WILSON MARCUS (†) Ph Pasadena A.B., Miami University, 1932 BRUNNER, EUGENE MITTELL (†) Ph Pasadena B.S., California Institute, 1933; M.S., 1934 BRYSON, ROBERT PEARNE Ge Los Angeles SON, HOBERT FRANKE A.B., University of California at Los Angeles, 1934 ROLAND ANTHONY ME Belen, New Mexico BUDENHOLZER, ROLAND ANTHONY B.S., New Mexico State College of Agriculture and Mechanical Arts, 1935 CHARTERS, ALEXANDER CRANE AE Portland, Oregon B.S., California Institute, 1934 B.S., University of Nanking, 1933; M.S., University of Michigan, 1935 CHILDERS, MILFORD CARLSON AE Los Angeles B.S., California Institute 1934; M.G. B.S., California Institute, 1934; M.S., CHIVENS, CLYDE CUTHEERTSON ME Burbank B.S., California Institute, 1935 CHU, DJEN YUEN \mathbf{Ph} Nanking, China B.S., National Central University, Nanking, 1924 CLANCY, CLARENCE WILLIAM Bi Highland, Illinois R.S., University of Illinois, 1930; M.S., 1932 CLARK, WILLIAM GILBERT Bi Altadena, California B.A., University of Texas, 1931 CLARKE, ROBERT ALMA (†) \mathbf{Ph} American Fork, Utah B.S., Brigham Young University, 1932; M.S., 1933 Pasadena CLAUSER, FRANCIS HETTINGER (†) AE B.S., California Institute, 1934; M.S., 1935 CLAUSER, MILTON URE (†) AE \mathbf{AE} Pasadena B.S., California Institute, 1934; M.S., 1935 COGEN, WILLIAM MAURICE (†) Ge Ge Los Angeles B.S., California Institute, 1931; M.S., 1933 COLMAN, PHILIP ABREY AE San Francisco A.B., Stanford University, 1934; M.S., California Institute, 1935 COOPER, WILLIAM CECIL Bi Pomona B.S., University of Maryland, 1929 Ph Lawrence, Kansas CRUMRINE, KENNETH CARL A.B., Kansas University, 1932; A.M., 1933 DAVIES, JAMES ALLMAN Ch H Ch ESanta Monica B.S., California Institute, 1935 DAWSON, CHARLES ALEXANDER, JR. Ge Hollywood B.S., California Institute, 1935 DEAHL, THOMAS JAY Ch Long Beach B.S., California Institute, 1935 \mathbf{Ph} DELSASSO, LEWIS ALEXANDER South Pasadena A.B., University of California at Los Angeles, 1930 DEWEES, NORMAN BRANSON ME San San Gabriel B.S., California Institute, 1935 DREYER, ROBERT MARX Ge Chicago, Illinois B.S., Northwestern University, 1934 DUNN, CLARENCE LINCOLN (†) Ch Juneau, Alaska B.S., University of Washington, 1932; M.S., 1933 ELCONIN, VICTOR Ma Los Los Angeles B.S., California Institute, 1933; M.S., 1935 ELMENDORF, CHARLES HALSEY Ph Beverly Hills B.S., California Institute, 1935

MATOR NAME SUBJECT EVANS, MILTON HARRISON Ge B.S., California Institute, 1935 Ch^{+} EYSTER, EUGENE HENDERSON B.Ch., University of Minnesota, 1935 FARQUHAR, JOHN PERCIVAL Ma B.S., Harvard College, 1935 Ch FINCH, LOUIS WILLIAM B.S., State College of Washington, 1935 Ph FINE, PAUL CHARLES B.A., University of Oklahoma, 1935 FIRESTONE, ROGER STANLEY Ph A.B., Princeton University, 1935 \mathbf{AE} FLEMING, MORTON KLYNE, JR. United States Naval Academy, 1922-26 and 1933-35 FOLLAND, DONALD FREEZE \mathbf{EE} B.S., University of Utah, 1933 FORSTER, GEORGE \mathbf{Ph} E.E., Lehigh University, 1914; M.S., California Institute, 1926 FOSTER, MARK GARDNER Pħ A.B., Miami University, 1935 Fowler, William Alfred Ph B. Eng. Physics, Ohio State University, 1933 \mathbf{CE} -Fox, JAMES MAY B.S., University of Utah, 1934 FREEMAN, ROBERT BRAMAN (+) ME. B.S., California Institute, 1932; M.S., 1933 GARNER, CLIFFORD SYMES Ch B.S., California Institute, 1935 GEVECKER, VERNON ARTHUR CHARLES CE B.S., Missouri School of Mines, 1931 GORDON, ADRIAN HUGH My B.S., California Institute, 1935 GRAHAM, ERNEST WASHBURN AE B.S., Purdue University, 1933 GRANT, CARL EDWARD ME B.S., United States Naval Academy, 1933 GREEN, EMERSON WARD B.S., California Institute, 1935 GREEN, NATHANIEL BALDWIN Ch Ge A.B., Stanford University, 1935 GRIEST, RAYMOND HOWARD \mathbf{EE} B.S., California Institute, 1932; M.S., 1933 GRIFFITHS, THOMAS WILLIAM CE B.S., California Institute, 1935 HALL, LEON \mathbf{Ph} A.B., Occidental College, 1931 HALL, NEWMAN ARNOLD Ma A.B., Marietta College, 1934 My HALLANGER, LAWRENCE B.S., California Institute, 1934 HARNEY, PATRICK JOSEPH My B.S., Clarkson College of Technology, 1931; M.S., California Institute, 1935 HAYNES, BENARTHUR CASTLE Mv B.S., California Institute, 1932; M.S., 1933 HAYNES, SHERWOOD KIMBALL (+) Ph A.B., Williams College, 1932 HEMMENDINGER, ARTHUR Ph B.A., Cornell University, 1933 HIGHBERG, IVAR EDMUND Ma B.A., Whitman College, 1932

HOME ADDRESS Los Angeles Wheaton, Minnesota Pasadena Seattle, Washington Isabel, Oklahoma Akron, Ohio Altadena Salt Lake City, Utah Pasadena Oxford, Ohio Lima, Ohio Salt Lake City, Utah Pasadena Pasadena St. Louis, Missouri London, England Rensselaer, Indiana Pasadena Pasadena Arcadia Hermosa Beach Santa Barbara Los Angeles Marietta, Ohio Alhambra Old Forge, New York Los Angeles Allston, Massachusetts Bernardsville, New Jersey

Spokane, Washington

MATOR SUBJECT HOME ADDRESS NAME HOWLAND, WALTER LAVERN Temple City AE B.S., California Institute, 1934; M.S., 1935 HSUEH, CHAO-WANG Ph. Shantung, China B.S., National University of Peking, 1931 HUANG, FUN-CHANG My Nanking, China B.S., National Central University, Nanking, 1926; M.S., California Institute, 1935 HUANG, HSIA-CHIEN Mv Nanking, China B.S., National Central University, Nanking, 1924; M.S., California Institute, 1935 HUENE, RUDOLF VON ME. Alhambra B.S., California Institute, 1934. Ma Los Angeles HYERS, DONALD HOLMES A.B., University of California at Los Angeles, 1933; M.A., 1934 INMAN, BYRON NOLL Ch E Pasadena B.S., California Institute, 1935 IPPEN, ARTHUR THOMAS (†) CE Aachen, Germany Diplom-Ingenieur, Technische Hochschule, Aachen, Germany, 1931; M.S., Cali-fornia Institute, 1935 Ives, PHILP TRUMAN Bi Amherst. Massachusetts Ives, PHILIP TRUMAN B.A., Amherst College, 1932; M.A., 1934 JACKSON, OSCAR BRANCHE Ph Fort Worth, Texas B.S., Texas Christian University, 1934; M.S., California Institute, 1935 UNIVERSITY CE Pasadena JENNISON, JAMES HENRY B.S., California Institute, 1935 JOHNSON, LEON WILLIAM Mv Washington, D. C. United States Military Academy, 1922-26 KANEKO, GEORGE SHINICHIRO EE Los Angeles B.S., California Institute, 1928 KATOW, SMOOT MASAKAZU ME Los Angeles B.S., University of California, 1935 KELLEY, VINCENT COOPER A.B., University of California at Los Angeles, 1931; M.S., California Insti-tute, 1932_ KEMNITZER, LUIS EMMETT (†) Ge KEMNITZER, LUIS EMMETT (†) Ge Altadena
 A.B., Stanford University, 1925; M.S., California Institute, 1933
 KENDALL, ROBERT COMBS (†) Ph Pasadena
 A.B., DePauw University, 1932; M.S., California Institute, 1933
 KENNEDY, EDWIN RUSSELL (†) Ch Los Angeles
 B.S., California Institute, 1933; M.S., 1934
 KLEIN, WILLIAM STACY Ph Los Angeles
 B.S., Oregon State College, 1932
 KNOBLOCK, FREDERICK DELERIDGE AE Detroit, Michigan
 B.S. Luiversity of Michigan 1926; M.S. 1927 Altadena Detroit, Michigan B.S.E., University of Michigan, 1926; M.S., 1927 KOONS, HARRY MONTFORD CE Los Angeles B.S., California Institute, 1935 KRAGHT, PETER ERVIN B.S., Washington State College, 1935 LANGMUIR, ROBERT VOSE My Lynden, Washington \mathbf{Ph} Englewood, New Jersey A.B., Harvard College, 1935 LARSEN, DELMAR H. Ch Hollywood B.S., California Institute, 1933 LASSETTRE, EDWIN NICHOLS Ch Billings, Montana B.S., Montana State College, 1933 LEPPERT, ELMER LOUIS B.S., California Institute, 1935 AE Monrovia LEVY, HENRI ARTHUR Ch Oxnard B.S., California Institute, 1935 LLOYD, PAUL EUGENE (†) Ph Los Angeles A.B., Stanford University, 1929

MATOR NAME SUBJECT Home Address Vancouver, British Columbia LOTZKAR, HARRY Ch B.A., University of British Columbia, 1934; M.A., 1935 LOVETT, BENJAMIN BARNES COMPTON AE Pasadena United States Naval Academy, 1922-26 and 1933-35 MACKINTOSH, CHARLES CEMack, Colorado B.S., Colorado College, 1933; M.S., 1934 MACLELLAN, DONALD DOMINIC (†) Ge Eureka, Utah E.M., Montana School of Mines, 1922; M.A., Columbia University, 1925 EER, OSCAR CARL My Washington, D. C. MAIER, OSCAR CARL United States Military Academy, 1921-25; M.S., Yale University, 1931 MALINA, FRANK JOSEPH AE Brenham, Texas B.S., Agricultural and Mechanical College of Texas, 1934; M.S., California Institute, 1935 MALONEY, FRED VERN \mathbf{EE} Los Angeles B.S., California Institute, 1935 MANSFIELD, KOBERT HUDDALL A.B., Cornell University, 1932 MARTIN, VICTOR JOHN B.S., University of Southern California, 1934; M.S., California Institute, 1935 EE Glendale \mathbf{Ph} Washington, D. C. MANSFIELD, ROBERT HUBBARD B.S., California Institute, 1934; M.S., 1935 MCCAULEY, ALLAN RUSSEL My Winnipeg, Manitoba, Canada B.A., University of Saskatchewan, 1928 McCullough, JAMES DOUGLAS (†) Ch Glendale MCCULLOUGH, JAMES DOUGLAS (T) Characteristics of California at Los Angeles, 1932 McKILLIP, JOHN C. SIEMER My Glov. United States Naval Academy, 1922-26 and 2933-35 McLEAN, WILLIAM BURDETTE Ph Santz B.S., California Institute, 1935 MCRAE, JAMES WILSON (†) EE Vant PADS Sc. University of British Columbia, 1933. Gloversville, New York Santa Barbara Vancouver, British Columbia B.App.Sc., University of British Columbia, 1933; M.S., California Institute, 1934 MENDENHALL, WILLIAM REES Ch Whittier A.B., Friends University, 1934 MENG, CHAO-YING (†) \mathbf{Ph} Peiping, China B.S., Yenching University, 1928; M.S., 1931 MERSMAN, WILLIAM ALVIN (†) Ma Alhambra B.S., California Institute, 1933; M.S., 1934 BiMICHENER, HAROLD DAVID Pasadena B.S., California Institute, 1934 NELSON, WILBUR CLIFTON \mathbf{AE} Flint, Michigan B.S., University of Michigan, 1935 OBERHOLTZR, WILLIAM EDWARD, JR. Mv Three Rivers, Michigan United States Naval Academy, 1922-26 and 1933-35 Odell, RAYMOND H. My Minneapolis, Minnesota B.Aero.E., University of Minnesota, 1932 EE Santa Cruz OLIVER, BERNARD MORE A.B., Stanford University, 1935 ONAKA, TAKEJI \mathbf{EE} Tottori, Japan B.S., University of Southern California, 1935 \mathbf{Ph} New York, New York OPPENHEIMER, FRANK B.A., Johns Hopkins University, 1933 OSBORN, ELEURT FRANKLIN (†) Ge Joliet, Illinois B.A., DePauw University, 1932; M.S., Northwestern University, 1934 OSBORNE, DARRELL WAYNE Ch Eagle Rock A.B., University of California at Los Angeles, 1935 OSTERGREN, RALPH HERMAN \mathbf{EE} Wheeler, Montana B.S., University of Washington, 1933 OVERHAGE, CARL F. J. (†) \mathbf{Ph} Santa Barbara B.S., California Institute, 1931; M.S., 1934

MAJOR SUBJECT NAME HOME ADDRESS PALMER, KENNETH JAMES Ch Oakland B.S., University of California, 1935 PASTERNACK, SIMON Ma Calgary, Alberta, Canada B.S., University of Alberta, 1935 PATTERSON, LEONARD SEARLES EE Los Angeles B.S., California Institute, 1935 PAXSON, EDWIN WOOLMAN Ma Long Island, New York B.S., California Institute, 1934 PICKERING, WILLIAM HAYWARD (†) \mathbf{Ph} Christchurch, New Zealand B.S., California Institute, 1932; M.S., 1933 PIERCE, JOHN ROBINSON (†) EE \mathbf{EE} Pasadena B.S., California Institute, 1933; M.S., 1934 PIPES, LOUIS ALBERT (†) \mathbf{EE} Pasadena B.S., California Institute, 1933; M.S., 1934 POPENOE, WILLIS PARKISON (†) Ge Ge Pasadena B.S., George Washington University, 1929; M.S., California Institute, 1933 POPOFF, EGOR PAUL CE San Francisco B.S., University of California, 1933; M.S., Massachusetts Institute of Tech nology, 1934 Potter, Warren Thomas, Jr. EE Altadena B.S., California Institute, 1935 POTTORF, NEWELL $^{\prime}$ Ph Salem, Ohio A.B., Oberlin College, 1934 POULSON, DONALD FREDERICK Bi Idaho Falls, Idaho B.S., California Institute, 1933 PUTNAM, WILLIAM CLEMENT Ge A.B., Stanford University, 1929; A.M., 1930 Los Angeles PYE, WILLARD DICKISON Ge Winter Park, Florida A.B., Oberlin College, 1935 RADER, LOUIS TELEMACUS \mathbf{EE} Vancouver, British Columbia B.A.Sc., University of British Columbia, 1933; M.S., California Institute, 1935 no. SIMON (+) EE Sult Lake City, Utah RAMO, SIMON (+) B.S., University of Utah, 1933 RINEHART, JOHN SARGENT \mathbf{Ph} Kirksville, Missouri B.S., Northeast Missouri State Teachers College, 1934; A.B., 1935 ROCKEFELLER, WILLIAM CURTIS AEPasadena B.S., California Institute, 1932; M.S., 1934 RODEE, WALTER FRED AE AEPasadena United States Naval Academy, 1922-26 and 1933-35 SCHAFER, SIDNEY Ge Madison, Wisconsin B.A., University of Wisconsin, 1930 SCHERB, IVAN VICTOR Ge Beverly Hills B.S., California Institute, 1935 SCHOMAKER, VERNER FREDERICK HENRY Ch Nehawka, Nebraska B.S., University of Nebraska, 1934; M.S., 1935 SCHULTZ, JOHN RUSSELL (+) Ge Lanark, Illinois A.B., University of Illinois, 1931; M.S., Northwestern University, 1933 WARTZ, JACK WILLIAM CE Hollywood SCHWARTZ, JACK WILLIAM B.S., California Institute, 1935 SCOVILLE, ALLAN ROMIG \mathbf{EE} Ogden, Utah B.S., California Institute, 1935 SEARS, WILLIAM REES AΈ Minneapolis, Minnesota B.Aero.E., University of Minnesota, 1934 SEIFERT, HOWARD STANLEY \mathbf{Ph} Pasadena B.S., Carnegie Institute of Technology, 1932; M.S., 1934 SHUGART, THOMAS REEDER Ph Waxahacl B.S., Texas Christian University, 1933 Waxahachie, Texas SIMMONS, EDWARD ERNEST, JR. \mathbf{EE} Los Angeles B.S., California Institute, 1934

252
Major SUBJECT NAME HOME ADDRESS Ch E Altadena SKINNER, DAVIS AYRES B.S., California Institute, 1934 SKOOG, FOLKE KARL (†) Bi Pasadena B.S., California Institute, 1932 \mathbf{Ph} SMITH, ROBERT ELLIS Quaker City, Ohio A.B., Muskingum College, 1933; M.S., University of Oklahoma, 1935 STENGEL, HANNS H. VON Ph Munich, Germany PHENS WILLIAM EDWARDS (+) Ph Brentwood, Missouri STEPHENS, WILLIAM EDWARDS (†) B.A., Washington University, 1932; M.S., 1934 STERN, BENJAMIN My Washington, D. C. United States Mililtary Academy, 1919-23 and 1931-32 Ch STITT, FRED BEALS (†) Pittsburgh, Pennsvlvania 1932; M.S., 1933 My Washington, D. C. B.S., Carnegie Institute of Technology, STRANGE, HUBERT ELLIS United States Naval Academy, 1922-26 and 1933-35 STRONG, THOMAS FOSTER B.S., University of Wisconsin, 1922 \mathbf{Ph} Pasadena TAN, CHIA-CHEN Bi Ningpo, China B.S., Soochow University, 1930; M.S., Yenching University, 1932 TAPLEY, GUSTAVUS SHEFFIELD CELos Angeles B.S., University of Southern California, 1924; M.S., 1929 TAYLOR, ANGUS ELLIS Ma Pomona B.S., Harvard College, 1933 TAYLOR, DONALD STINSON \mathbf{Ch} McMinnville, Oregon B.A., Linfield College, 1935 TRAMPE, OLIVER CARL ChWauwatosa, Wisconsin B.A., Carroll College, 1935 TREGIDGA, ANGUS CAMPBELL \mathbf{Ph} Vancouver, British Columbia B.A., University of British Columbia, 1932; B.App.Sc., 1933; M.A., 1935 UHRIG, LEONARD FREDERICK Ge Dayton, Ohio Geological Engineer, University of Cincinnati, 1934 My Washington, -S.. Yale University, 1925 Washington, D. C. WAINER, PERRY M B.S., University of Delaware, 1911; M.S. WALLMAN, DICK HERMAN My Yarmouth, Iowa B.A., Parsons College, 1934 WALSETH, ERLING SANBORN CEClear Lake, South Dakota B.S., South Dakota State College, 1935 WALSTROM, JOHN ERWIN Ph Keene, New Hampshire B.S., New Hampshire State University, 1932; M.A., Wesleyan University, 1934 \mathbf{Ph} Pasadena WAYLAND, JAMES HAROLD (†) B.S., University of Idaho, 1931; M.S., California Institute, 1935 WEBB, DONALD LOOMIS (†) $\mathbf{M}\mathbf{a}$ Tucson, Arizona B.S., University of Arizona, 1931; M.S., 1933 BB, ROBERT WALLACE (†) Ge WEBB, ROBERT WALLACE (†) Los Angeles A.B., University of California at Los Angeles, 1931; M.S., California Institute, 1932 WELGE, HENRY JOHN (†) Ch. Long Beach B.S., University of Illinois, 1929; M.S., California Institute, 1932 WHELAN, THOMAS MURRAY AE Pasadena United States Naval Academy, 1922-26 and 1933-35 WIDESS, MOSES B. (†) \mathbf{EE} Pasadena B.S., California Institute, 1933; M.S., 1934 \mathbf{Ph} Granville, Ohio WILEY, HAROLD FORBES B.A., Denison University, 1935 AEWILKERSON, ROBERT TUGGLE Stockton B.S., University of California, 1935 WILLIAMS, CLARENCE STRONG My Los Angeles LL.B., Northwestern College of Law, 1914

	MATOR		
Name	SUBJEC	т	Home Address
WILSON, ROBERT WARREN (†)	Ge	Los	s Angeles
B.S., California Institute, 1930; M.S.	, 1932 -		0
WINSTEIN, SAUL	Ch	Los	s Angeles
A.B., University of California at Los	Angele	s, 19.	34; M.A., 1935
WONG, WALTER CHONG	\mathbf{EE}	Ho	nolulu, T. H.
B.S., University of Hawaii, 1934			
WOOD, CARLOS CLAUDE	\mathbf{AE}	Sto	ckton
A.B., College of the Pacific, 1933; M.	.S., Cali	forni	a Institute, 1934 and 1935
WOOD, LOUVAN ELBERT	My	Pas	sadena
B.Sc., Alma College, 1929; M.S., Cal	lifornia	Insti	tute, 1935
WOOLDRIDGE, DEAN EVERETT (†)	\mathbf{Ph}	Ok	lahoma City, Oklahoma
B.A., University of Oklahoma, 1932;	M.S., 1	933	•
WRIGHT, FREDERICK HAMILTON	\mathbf{Ph}	Wa	shington, D. C.
A.B., Haverford College, 1934			
YIN, HUNG CHANG	Bi	Pei	ping, China
B.S., Nankai University, Tientsin, 192	29		
YOUNG, BRADLEY HOBART	\mathbf{AE}	\mathbf{La}	Habra
B.S., California Institute, 1935			
Young, Larry Love	\mathbf{Ph}	Sal	t Lake City, Utah
B.S., University of Utah, 1934			· · · · ·
ZIMMERMAN, DON ZABRISKIE	My	Wa	shington, D. C.
B.A., University of Oregon, 1924; M	[.A., 192	29;1	United States Military Acad
emy, 1925-29			

254

Undergraduate Students

Students whose names are starred attained honor standing during the preceding year.

SENIOR CLASS

NAME	COURSE	Option	Home Address
Baker, Carroll Royer	Eng.	\mathbf{ME}	Portsmouth, Virginia
Beckley, William Bruce	Eng.	\mathbf{EE}	Las Vegas, Nevada
Best, Charles Ward	Sci.	\mathbf{Ch}	Pasadena
Bingham, William Eugene	Sci.	A.Ch	Los Angeles
Bishop, Arthur Lyman	Sci.	$\Lambda.Ch$	Long Beach
Blodgett, Donald Eugene	Eng.	ME	South Pasadena
Boothe, Raymond H. F.	Eng.	CE	Los Angeles
Bucknell, Wilson Henn	Eng.	\mathbf{EE}	Los Angeles
Burnight, Thomas Robert	Sci.	\mathbf{Ph}	Akron, Iowa
Bush, Kenvon T.	Sci.	A.Ch	Seattle, Washington
Cain. Claude Walters II	Eng.	\mathbf{AE}	Chicago, Illinois
Campbell, William Edward, Jr.	Sci.	A.Ch	Pasadena
Carley, Glenn Ray	Sci.	Ph	Butte Montana
Carr. Robert Broadwell	Sci.	Ge	Glendale
Carroll, George Edward	Eng.	ME	Los Angeles
Cohen, Jeffrey S.	Sci	Ph	Hollywood
Colvin, Hugh Frank	Sci.	A.Ch	Walnut Park
Condon, John	Eng.	ME	Los Angeles
Cortelvou, Curtis Gardner	Eng.	ME	Los Angeles
Creal, Albert	Eng.	CE	Los Angeles
Dauben, Elmer Joseph	Sci	Ă.Ch	Culver City
Davis, Frank W.	Eng	MĚ	Pasadena
Dickinson, Holley Buckingham	Eng	AE	Hollywood
Dilworth, Robert Palmer	Sci ⁵	Ma	Hemet
Douglass, Malcolm Ellsworth	Eng	ME	Pasadena
Dunn, Louis G.	Eng.	AE	Transvaal. South Africa
Elconin, William	Eng.	ÊÊ	Los Angeles
Elliott, Robert Dunshee	Sci	Ph	Clarendon, Virginia
Fahrmann, Minor Louis	Eng.	ME	El Monte
Ferguson, Stuart Russell	Sci.	A.Ch	Puente
Fowler, Fenton S.	Eng.	ME	Los Angeles
Frazier, Francis Virgil	Eng.	\mathbf{CE}	Los Angeles
Frost, Arthur Mitchell	Eng.	\mathbf{EE}	Huntington Beach
Gardner, Robert Irving	Eng.	ME	Los Angeles
Gates, John Irwin	Sci.	Ch	Torrance
Geddes, Truman Gray	Eng.	ME	San Diego
Gelder, Robert	Sci.	A.Ch	Los Angeles
George, John Wesley	Sci.	Ge	Santa Barbara
Gerfen, W. Howard	Eng.	CE	Monterey Park
Getzman, Edwin Samuel, Jr.	Eng.	ME	South Pasadena
Goodheart, Clarence Francis	Eng.	\mathbf{EE}	Roscoe
Goodwin, Henry John	Eng.	CE	Los Angeles
Griffith, Everette Elijah	Sci.	Ch	Woodland
Hamacher, Howard Franklin	Sci.	A.Ch	Spokane, Washington
Hammond, Paul Harvey	Eng.	CE	Spokane, Washington

NAME	Course	Option	Home Address
Hand, Ross Lowell	Eng.	\mathbf{EE}	Burbank
Hartlein, Robert Leonard	Eng.	ME	Pasadena
Haver, Ralph Lawrence	Eng.	ME	San Fernando
Heath. Charles Oswald	Eng.	ME	Montebello
Heitz, Robert George	Sci.	Ch	Huntington Beach
Henderson, Everett Benedict	Eng.	ME	Beverly Hills
Hicks Bruce Lathan	Sci	Ph	Pasadena
Hinshaw, Meral William	Eng	ME.	Pasadena
Humason William Dowd	Sci.	Bi	Pasadena
Icham Arthur Farl II	Eng	MF	Redlands
Isnas Robert Lee	Eng.	CF	St Paul Minnecota
Janes, Robert Lee	Eng.		Son Marino
Jensen, nay	Eng.	UE MF	Dhooniy Arizona
Jeraula, Robert L.	Eng.		Phoenix, Arizona
Jones, Clyde Branson	Eng.	M E	wapena, innois
Jones, Paul S.	Eng.	CE	Los Angeles
Jones, Vincent K., Jr.	Eng.	CE	Denver, Colorado
Jordan, Charles B.	Sci.	\mathbf{Ph}	Los Angeles
Kasnicka, Edward John	Eng.	\mathbf{AE}	Monrovia
Kent, Robert Dana	Sci.	A.Ch	Covina
Kiger, Wallace L.	Eng.	\mathbf{CE}	Pasadena
Kimura, Ben	Eng.	\mathbf{AE}	Compton
Klocksiem, John Paul	Eng.	\mathbf{AE}	Long Beach
Krantz, Channing Henry	Eng.	\mathbf{EE}	El Monte
Kurihara, Hisayuki	Eng.	\mathbf{AE}	Pasadena
Lauritsen, Tom	Sci.	\mathbf{Ph}	Pasadena
Lew, Harry W.	Sci.	\mathbf{Ph}	Los Angeles
Lewis, Glenn Harry	Eng.	\mathbf{EE}	Pavette, Idaho
Marsh, Robert Henry	Eng.	\mathbf{EE}	Pasadena
McIntyre, Robert Alfred	Eng.	ME	Maywood
McMahon, Michael Martin	Eng.	EE	Pomona
McBary, Willard Lee	Sci	Bi	Los Angeles
Meneghelli Hugo Antonio	Eng	EF	Hollywood
Milan Leo Joseph	Sei	A Ch	North Hollywood
Morse Charles	Fng	CF	Log Angeles
Mullon Conned P	The m	TAR	Dos Angeles
Numer, Conrau A.	Eng.		Portland, Oregon
Nalce, Guy Kussen	Eng.	ME	Los Angeles
Nerson, Loyal Edward	Sci.	Ge	Pasadena
Nestier, wasson waiter	Eng.	L'F	Pasadena
Nichols, Dean	Sci.	BI	La Jolla
Nichols, Robert Maurice	Eng.	EE	Giendale
Nollan, John Lloyd	Eng.	AE	Los Angeles
Nutting, Perley Gilman	Sci.	Ph	Washington, D. C.
Ohashi, George Yoshio	Eng.	\mathbf{EE}	Los Angeles
Olson, Edgar Williams	Eng.	\mathbf{EE}	Glendale
Paller, Jack	Eng.	\mathbf{CE}	Los Angeles
Petersen, Richard John	Sci.	A.Ch	Redlands
Peugh, Verne Leon	Eng.	\mathbf{CE}	Pasadena
Quarles, Miller Winthrop, Jr.	Sci.	Ge	San Diego
Rector, Eugene Martin	Eng.	\mathbf{EE}	Long Beach
Richey, William Coulter	Eng.	\mathbf{EE}	Los Angeles
Rosen, Moe	\mathbf{Eng} .	ME	Sierra Madre
Salisbury, Orange James, Jr.	Eng.	ME	Pasadena
······································	· 8·		

NAME	Course	OPTION	Home Address
Schaffner, Paul Corwin	Eng.	\mathbf{EE}	Upland
Scheer, Bradley Titus	Sci.	\mathbf{Bi}	Hollywood
Schneider, Paul J.	Sci.	Bi	Berkeley
Seaman, James Roy, Jr.	Eng.	\mathbf{EE}	Hollywood
Serrell, Peter Van Horne	Eng.	ME	Redlands
Shapiro, Herbert Barnett	Eng.	ME	Los Angeles
Simpkinson, Arthur Albert	Eng.	CE	Canoga Park
Sklar, Maurice	Sci.	A.Ch	Los Angeles
Smith, Apollo Milton Olin	Eng.	\mathbf{AE}	Inglewood
Snow, Neil W.	Eng.	CE	Altadena
Spalding, Luther Payne	Sci.	\mathbf{Ch}	Phoenix, Arizona
Streib, John Frederick	Sci.	\mathbf{Ph}	Pasadena
Swanson, Walfred Ernest	Eng.	CE	Hollywood
Thompson, Tyler F.	Sci.	\mathbf{Ph}	Corona
Unholtz, Karl	Eng.	\mathbf{EE}	Los Angeles
Van Riper, Dale Hatfield	Eng.	\mathbf{ME}	Bakersfield
Vermeulen, Theodore	Sci.	A.Ch	Los Angeles
Veysey, Victor	Eng.	\mathbf{CE}	Los Angeles
Waddell, John H.	Eng.	\mathbf{EE}	Santa Monica
Watanabe, Kenichi	Sci.	\mathbf{Ph}	Honolulu, T. H.
Watt, Chauncey Ward	Eng.	\mathbf{EE}	Long Beach
Watts, Euclid Vance	Eng.	\mathbf{AE}	Honolulu, T. H.
Webb, John Leyden	Sci.	Bi	Los Angeles
Weber, Bruce Travis	Sci.	Ph	Brooklyn, New York
Whipp, David M.	Eng.	\mathbf{EE}	Glendale
Wiget, Clark Hamilton	Eng.	\mathbf{ME}	Concord
Wood, Reuben	Sci.	\mathbf{Ch}	Monrovia
Works, John Dwight	Eng.	ME	Los Angeles
Young, Donald Laurence	Eng.	\mathbf{EE}	Pasadena

JUNIOR CLASS

NAME	Course	Option	Home Address
Ambroff, Michel	Eng.	\mathbf{ME}	Los Angeles
*Ashkenas, Irving Louis	Eng.	\mathbf{AE}	Los Angeles
Auger, Alfred Dudley	Eng.	\mathbf{CE}	Hollywood
Austen, John Reynolds	Eng.	\mathbf{ME}	Los Angeles
Austin, Hoyt	Eng.	ME	Coronado
Axelrod, Joseph	Sci.	\mathbf{Ch}	Los Angeles
Belzer, Thomas Russell	Sci.	Bi	Portland, Oregon
Benton, Ralph Stahlnaker	Eng.	\mathbf{ME}	Phoenix, Arizona
Blue, John	Sci.	A.Ph	Monterey Park
Boller, Harry	Eng.	\mathbf{EE}	Alhambra
Bonham, Elliott Hinman	Eng.	\mathbf{ME}	Pomona
Bower, Clark Douglass	Eng.	ME	San Luis Obispo
Boyd, Willis Blair	Eng.	\mathbf{ME}_{\perp}	Hillsboro, Ohio
Browne, James Bell	Eng.	(ME)	Hollywood
Bussard, Gordon Lucas	$=$ Eng. \square	ME	Spokane, Washington
Campbell, Robert Samuel	Eng.	\mathbf{EE}	Hollywood
Carrick, Harry Hall	Eng.	(EE)	Los Angeles
Chatham, Carroll	Sci.	Ch	San Francisco
		\	

¢.E

NAME	Course	Option	Home Address
Cornwall, Ellsworth William	Eng.	\mathbf{ME}	Portland, Oregon
Davis, Thomas V.	Eng.	\mathbf{CE}	Los Angeles
*DeVault, Don Charles	Sci.	\mathbf{Ch}	Inglewood
Dion, Fred Eugene	Eng.	ME	Glendive, Montana
*Dodson, Richard Wolford	Sci.	Ch	Kirksville, Missouri
Dorwart, George Martin	Eng.	ČĒ	Pasadena
Dowd Munson White	Sci er	- Ph	El Centro
Droke Clarence Bonald	Sci E	Ch	L og Angeleg
Dunbar Bruce W	Sci.	A Ch	Pagadena
*Edwards John S. Ir	Sci	Ch	Goleta
Ellow William	Eng	ME	Monrovia
Enery, william Enicl-con Vincil	Eng.	ME	
E-hener Tod	Eng.	10112	Los Aligeles
ranmer, ieu	Eng.		Banta Darbara
rarnnam, willard	Eng.		Send, Oregon
Fenzi, warren Emanuele	Eng.	UL	Santa Barbara
Fleming, Lawrence 1.	Eng.	ME	Los Angeles
Frost, Holloway	Eng.	EE	Fort Leavenworth, Kansas
*Gates, Charles Frederick	Sci.	A.Ph	Torrance
Gerlough, Daniel Lauder	Eng.	\mathbf{EE}	Palo Alto
Gilbert, Matthew James	Sci.	Ge	Beverly Hills
Goodell, Richard Rohrer	Sci.	Ph	Puente
*Griffis, LeVan	Eng.	\mathbf{CE}	Corvallis, Oregon
Grobecker, Alan John	Sci.	\mathbf{Ph}	San Diego
Hadley, Charles Franklin	Eng.	\mathbf{EE}	Redlands
*Harper, Thomas Sinclair	Sci.	\mathbf{Ph}	Denver, Colorado
Hayward, Russell Edward	Sci.	Ge	Glendale
Hopkins, Boyd Richard	Sci.	Ph	Ogden, Utah
Hopkins, Henry Stuart	Eng.	ME	Butte, Montana
Horkey, Edward James	Eng.	AE	La Canada
Horne, George Henry	Sci	A.Ch	Glendale
Horovitz, Leon	Sci	Bi	Hollywood
Johnson Carl Burdett	Eng	ME	Hollywood
* Jones Bobert Caldwell	Sci	Ch	Valima Washington
Kapin Herbert Russell	Sci.	A Ch	Les Angeles
Kally Buyon Hannon	Eng	MF	Los Angeles
Kinghall Down	Eng.	10112	Holly wood
Kinlow John Canr	Eng.	ME	Evanston, minois
Kinley, John Cary	Eng.	A Ch	Tuisa, Oktanoma
Kostoch, Kobert	501.	A.Cn	Los Angeles
Kremers, Henry Edward	Eng.	ME	Pasadena
LaBoyteaux, Elisworth	Eng.	ME	Eureka
Larson, Carl Elmer	Eng.	CE	Arcadia
Leard, Robert Marshall	Sci.	A.Ch	Los Angeles
Legge, John Allan	Sci.	\mathbf{Ph}	Las Cruces, New Mexico
Leggett, Jasper Ridgley	Eng.	\mathbf{EE}	Los Angeles
Li, Yuan Chuen	Eng.	\mathbf{AE}	Chengtu, China
Lilly, John Cunningham	Sci.	Bi	St. Paul, Minnesota
Lockwood, Robert Bruce	Sci.	Ge	Glendale
Lycett, Eustace Arden	Eng.	\mathbf{ME}	Carlsbad, New Mexico
MacMichael, Ethan	Eng.	\mathbf{EE}	Piedmont
Maescher, Robert Edward	Sci.	A.Ch	Los Angeles
Mahoney, Robert Matthew	Eng.	CE	Los Angeles
Mann, Ğeorge Edward, Jr.	Eng.	\mathbf{AE}	El Centro
	0		

NAME	Course	Option	Home Address
McLaughlin, Stuart Watson	Sci.	\mathbf{Ch}	Altadena
McSparran, Winthrop Gilman	n Eng.	ME	Yokohama, Japan
Merriam, John	Eng.	ME	San Bernardino
Miller, Harry Heyburn	Sci	Ch	Bend, Oregon
Miller, Wendell Bower	Eng.	EE	Hollywood
Milliken, Charles Smyth	Eng	EE	Pasadena
Moncrief Ernest	Eng.	ME	Orosi
Montag George Delmer	Eng	EE	Portland Oregon
Moore Walter Leon	Eng	CE	Pasadena
Morgan Bruce F Jr	Eng	EE	Seattle Washington
Nash William Francis	Eng.	ME	San Diego
Nellis Donald Charles	Sci ⁰	Ch	Burbank
Nojima Noble	Eng	AE	Long Beach
Nolte Claude Buron	Sci	G	Long Deach Los Angeles
Offeman Richard Fril	Sci.	ACh	Hollywood
*Olda Bohart Horner	Sci.	Dh Dh	Los Angeles
Owen Neel LeGrande In	Eng	ти FF	Los Angeles
Dorly Neel Behartson	Eng.		Los Aligeres Domono
Park, Noel Robertson	SCI.	A.Ch	Fomona West Les Assesses
Parker, Robert Gray	Sci.	A.Ch	West Los Angeles
Peek, Howard Marion, Jr.	Sci.	A.Ch	Phoenix, Arizona
Penn, William Lee	Eng.	EE	Manila, Philippine Islands
Peterson, Joseph James	Eng.	ME	Pachuca, Hgo., Mexico
Poggi, Martin Joseph	Eng.	AE	Nutley, New Jersey
*Pressman, David	Sei.	Ch	Los Angeles
*Price, Edward Thomas, Jr.	Sci.	Ph	Claremont
Radcliffe, Fremont Fisher	Sci.	Ch	Pasadena
Radovich, Frank	Sci.	A.Ch	Los Angeles
Rechif, Frank Albert	Eng.	EE	Tucson, Arizona
Ridgway, Richard Lee	Eng.	\mathbf{EE}	Los Angeles
Rollow, Douglas Keesee	Eng.	ME	Los Angeles
*Rosencranz, Richard, Jr.	Sci.	Ch	Evansville, Indiana
Sandberg, T. Robert	Sci.	A.Ch	Long Beach
Schmidt, Walter Malcolm	Sci.	A.Ch	Los Angeles
Schombel, Leonard Frederick	Sci.	Ge	Alhambra
Schuman, Daniel	Eng.	\mathbf{CE}	San Diego
Segelhorst, August Van Ness	Eng.	\mathbf{ME}	Taft
Selberg, John Peter	Eng.	\mathbf{ME}	Portland, Oregon
Sharp, Harold W.	Sci.	A.Ph	Santa Paula
*Shaw, Thomas Newton	Sci.	\mathbf{Bi}	Honolulu, T. H.
Sheppard, Charles Wilcox	Sci.	\mathbf{Ph}	Coldwater, Ontario, Canada
Sheppard, Herbert Ramsey	Eng.	\mathbf{CE}	Los Angeles
Shimer, John Morris, Jr.	Eng.	ME ·	Dallas, Texas
Smith, Harold Lewis	Eng.	CE	Naches, Washington
Smith. Joe Mauk	Sci.	Ă.Ch	Pasadena
Smith, Wayne Winton	Sci.	Ph	Lawndale
Snelling, Wilbur Fisher	Eng.	ÂĒ	Penryn
Stackhouse, William V	Eng.	AE	Pasadena
Sullwold, John	Eng.	ME	Sierra Madre
Swain, Robert K.	Eng.	ĀĒ	Monrovia
Teague, Donald Spencer	Eng	ĒĒ	Santa Paula
Test. Meyer Joseph	Sci	Ph	Kansas City, Missouri
a conji na oj or o obcepni	~~~	~ 11	is anous only in 1950 and

NAME	Course	Option	HOME ADDRESS
Townsend, Robert Dawson, Ju	r. Sci.	\mathbf{Ph}	Arcadia
Tsao, Chi-Cheng	Eng.	\mathbf{AE}	Kiangsu, China
Tsubota, George Yoshio	Eng.	\mathbf{AE}	Riverside
Tulagin, Vsevolod	Sci.	\mathbf{Ch}	Hollywood
Tyler, John Garnett	Sci.	Bi	Beverly Hills
Van Der Werff, Jay	Eng.	\mathbf{ME}	Pasadena
Van Fleet, John Ricard	Eng.	CE	Santa Barbara
Warner, Hugh Francis	Eng.	\mathbf{AE}	San Pedro
Watson, James Wendell	Sci.	\mathbf{Ph}	Grand Island, Nebraska
Webster, Martin Haskell	Eng.	ME	Los Angeles
Wetmore, William Owen	Eng.	ME	Huntington Park
Wheeler, Walter George	Eng.	\mathbf{ME}	Van Nuys
Wileman, Edward Earl	Eng.	\mathbf{AE}	Fillmore
Woolsey, Charles Cramer	Sci.	A.Ch	Alhambra
Wylie, W. Gordon	Eng.	\mathbf{AE}	Whittier
Yale, William Dickinson	Sci.	A.Ch	Burbank
Zimmerman, Albert Herman	Eng.	\mathbf{EE}	Pasadena

SOPHOMORE CLASS

NAME	Course	Home Address
Ahlroth, Carl Wilhelm	Sci.	Los Angeles
Allen, Richard Harvey	Sci.	San Diego
Althouse, William S., Jr.	Eng.	Glendale
Arvin, George Howard	Sci.	Long Beach
Baker, John Raymond	Eng.	San Marino
Ballreich, Newell	Sci.	Los Angeles
Balsley, James Robinson	Sci.	La Canada
Barry, Robert Joseph	Eng.	South Pasadena
Bauer, Charles Henry	Sci.	Carmel
*Beavon, David Kent	Sci.	Los Angeles
Blake, John Bildner	Eng.	Lynwood
Borgeson, Lawrence G.	Eng.	Pasadena
Bowman, John Cowan	Eng.	San Diego
Brenner, William Carl	Eng.	Pasadena
Brown, Claude H., Jr.	Sci.	Los Angeles
Brush, John Maxwell	Sci.	Pasadena
*Cardwell, William Thomas	Sci.	Pasadena
Carlson, Roland Willard	Eng.	Long Beach
Carr, Robert Edgar	Sci.	Pasadena
Chung, David	Eng.	Los Angeles
Clarke, Charles William •	Eng.	Los Angeles
Cowie, Roger Harrison	Eng.	Minneapolis, Minnesota
Craig, George	Eng.	Las Vegas, Nevada
Croft, William Frederick	Sci.	Glendale
Crowe, John William	Sci.	Santa Cruz
Crozier, George Olds	Eng.	Monrovia
Custer, Robert S.	Sci.	Glendale
Davidson, Donald Douglas	Sci.	Glendale
Davidson, Robert C.	Sci.	South Pasadena
Davies, Claude Edward	Sci.	Olive

63

NAME	COURSE	Home Address
Dennis, Paul Arthur	Sci.	Los Angeles
Dixon, Blaine A., Jr.	Sci.	Glendale
Dougherty, Jack Francis	Sci.	Beverly Hills
Downing, Arthur Clifford	Eng.	Los Angeles
DuFresne, Armand Frederick	Eng.	San Diego
Ellings, Arthur Clement	Sci	Santa Barbara
Elliott, Bruce Cass	Eng	Brentwood Heights
*Ellis, Herbert Bailey	Eng.	Los Angeles
Engelder, Paul Oscar	Eng.	Douglas. Arizona
Estrada Julio Enrique	Sci	Guavaguil Ecuador
Evans Henry King	Eng	Santa Maria
Farneman John D	Eng.	Hollywood
Folking Richard Wilson	Eng.	Redlands
Forward Richard Blair	Eng. Eng	Sonta Barbara
Freeda William John	Eng. Sei	Oklahoma City Oklahoma
Friend Corl Frederick	Eng	Washington D.C.
Friding Edward Nathanial	Eng.	Washington, D. C.
Callaghan Caanga Candan	Eng.	Hollywood
Ganagner, George Gordon	SCI.	Glendale
Gon, Peter Clayton	Eng.	Beverly Hills
Grainger, Boyne B.	Eng.	Redondo Beach
*Graybeal, Oran Avery, Jr.	Eng.	Beverly Hills
Gregory, Chris	Sci.	Hollywood
Griswold, Edgar Allen	Sci.	Los Angeles
Harker, Ralph W.	Eng.	Los Angeles
*Harris, Clyde Winger	Sci.	Lakewood, Ohio
Hobson, Charles Walter	Eng.	Alhambra
Holmes, George B.	Eng.	Duarte
Horine, Carlton Leon	Sci.	Cristobal, Canal Zone
Hotz, George Marion	Eng.	Los Angeles
Hulbirt, Lowell Harrison	Sci.	Glendora
Ivanoff, Nickolas Giorgievich	Eng.	Los Angeles
Jewett, Frank Baldwin, Jr.	Sci.	Short Hills, New Jersey
Johnson, Evan Albert	Eng.	La Habra
Jones, Ralph Wilson, Jr.	Eng.	Pasadena
Kazan, Benjamin	Sci.	New York City, New York
Keller, Samuel Harris	Eng.	Glendale
Kelly, Leroy Bruce	Eng.	Alhambra
Knell, David J.	Sci.	Pasadena
Knight, Jack William	Sci.	Glendale
Kolb. Louis Lawrence	Sci.	Los Angeles
Konecnik, John	Eng.	Los Angeles
Kyhal. Dalimil	Eng.	Prague, Czechoslovakia
Lable, Robert Cain	Sci.	Hollywood
*Lavender, Harrison Morton	Sci.	Warren, Arizona
Lentz John Jacob	Eng	Los Angeles
Levet Melvin Newton	Sci	Monterey Park
Levin Gerald Balfour	Sci	Los Angeles
Levit Robert Jules	Sci	San Francisco
Levy Henry J	Eng	Los Angeles
*Lowis Clay Warden	Sci	Fort Scott Kansas
*I lewellyn Fred Faton	Eng	Clandala
Lagebood John Allan	Eng.	Uchuale
Lockneed, John Anan	rang.	110Hy wood
	152	•

NAME	Course	Home Address
Lowell, Arthur Carter	Sci.	San Francisco
Luckenbill, David Brown	Sci.	Redlands
MacLean, John Bartlett	Sci.	Evanston, Illinois
Maines. Noble	Sci	Pasadena
McGraw John Thomas	Eng	Los Angeles
McLaan John Godfrey	Soi	Los Angeles
McMillon Bishard Stashton	Bel.	LOS Aligeles
Field	To a second	Decedence
Moonlow Thomas Moredith	Eng.	Lasaucha Son Diogo
Meanley, Thomas Meredith	Sci.	San Diego
Metzner, Robert G.	Eng.	Los Angeles
Milburn, William Edward	Eng.	Redondo Beach
Minasian, John K.	Eng.	Los Angeles
Mueller, John Calvin	Sci.	Los Angeles
Murad, Sami Butrus	Eng.	Baghdad, Iraq
Nickerson, Douglas Blain	Sci.	Redlands
North, Harper Qua	Sci.	Los Angeles
O'Connor, Chadwell	Eng.	Boston, Massachusetts
Ogg, James Truman	Eng.	Eagle Rock
Osborn, George Havice	Eng.	Azusa
Pahst, Alton Link	Eng	Pasadena
Page, Franklin Homer, Jr	Sci	San Diego
*Parker John E	Sci	Pagadana
Pest John McCowen	Sei.	South Decadena
Piro Losoph Frenk	En.	Log America
Dowton Educin Lemett	Eng.	Los Angeles
Forter, Edwin Jewett	Eng.	whittler
Poweil, Josian Whittaker, Jr.	Sci.	Florence, Alabama
Rhett, William	Eng.	Maywood
Ropp, William Franklin	Eng.	Glendale
Ross, Charles Robertson	Eng.	Seattle, Washington
Rowell, Richard Merrill	Sci.	Lancaster
Rudkin, George Thomas	Sci.	San Marino
Rynearson, Garn Arthur	Sci.	Van Nuys
Saurenman, Phillip E.	Eng.	Pasadena
Scully, Charles Norman	Sci	Pasadena
Shepherd, Philip Frick	Eng	Altadena
*Sherwood David Mary	Sci	Palo Alto
Sidlon Arthur William	Eng	San Bannardina
Sighart Paul Charles	Eng.	Santo Deula
Simmong W. Croig	Sci.	Janua rauta
Similarity Oler Mersler	Sci.	Honywood
Smith, Clay Laylor	Sci.	Los Angeles
Smith, Fred Lester	Sci.	Leadville, Colorado
Smith, Robert Louis	Eng.	Hollywood
Snyder, Willard Mitchell	Sci.	Hermosa Beach
Stone, Roland Cruse	Sci.	Ogden, Utah
Tejada, Luis Hernan	Eng.	La Paz, Bolivia
Thomas, Robert Coggeshell	Eng.	Hollywood
Tilker, Paul Owen	Eng.	Los Angeles
, Tobin, Bernard Milton	Sci.	Brooklyn, New York
Twiss, William Edward	Eng.	Pasadena
Van Dusen, Charles Albert	Eng.	Baltimore, Maryland
Van Horn, James W	Eng	Los Angeles
Velazonez Jose Luis	Eng	Mexico City, D. F., Mexico
v clazyuca, suse Luis	iong.	MULLICO ORUS D. P., MULLICO

COURSE

NAME

113.315	COURSE	110/11
Voorhees, Stanley Van	Eng.	Hollywo
Wald, George Gustav	Sci.	Alhamb
Walker, Albert Clark	Sci.	Fresno
Watson, Sam Eugene	Sci.	Pasader
Weinberger, Edward Lee	Sci.	Los Ang
Westheimer, Joseph Freyer	Eng.	Los Ang
Wilkinson, Lupton Allemong	,	
Jr.	Eng.	Baton R
Williams, William Robert	Eng.	Pasaden
Williamson, John Bridges	Eng.	Fontana
Wilson, Gardner Pond	Eng.	Fresno
*Wimpress, Richard Norman	Sci.	Glendal
Windsor, Emanuel	Sci.	Los Ang
Wolfberg, Stanley T.	Eng.	Los Ang
*Wood, Homer Jesse	Eng.	Porterv
Youngs, Homer Smith	Sci.	Glendal
Zezukevich, Victor Boris	Eng.	Harbin,
	5.	

HOME ADDRESS Hollywood Alhambra Fresno Pasadena Los Angeles Los Angeles

Baton Rouge, Louisiana Pasadena Fontana Fresno Glendale Los Angeles Los Angeles Porterville Glendale Harbin, Manchukuo

FRESHMAN CLASS

Νλμε

Agin, Henry Anderson, Clarence Russell Anderson, Noah Herbert, Jr. Andrews, Richard Allworth Asakawa, George Avenali, Peter Axtman, Grice Battle, John Allen Beck, Duane Wesley Berg, William Eugene Bishop, Richard Hawley Black, Jack William Bowers, Orrin C. Bradshaw, Richard R. Bragg, Kenneth Rankin Brahtz, John Frederick Braithwaite, James William Brown, George Reynolds Brown, Perry H. Brown, William Emil Caldwell, Donald Andrew Carstarphen, Charles Frederick Carter, Robert Trissel Caulfield, Henry Patrick, Jr. Clark, Stephen Cutter, III Clarke, Edmund Willcox Conant, Ellsworth Eugene

Cooper, Robert William Cox, Robert Osborne

HOME ADDRESS Hollywood Los Angeles Texarkana, Texas Glendale San Diego Redwood City South Pasadena Los Angeles Los Angeles Round Mountain, Nevada Milwaukee, Wisconsin Hollywood Walnut Park Walnut Park San Marino Denver, Colorado Arcadia Colorado, Texas Los Angeles Los Angeles San Diego Denver, Colorado Glendale Hollywood Pasadena Los Angeles Occidental Negros, Philippine Islands Los Angeles Watertown, New York

NAME

Davis, Harry Owens, Jr. Davis, Wallace Fredrick Degnan, Thomas Junior Joseph Devirian, Philip Sarkis Dibble, Barry, Jr. Dickey, Frank Host Diehm, Walter Edmundson, Dermot Walpole Elms, James Cornelius, IV Engelhardt, Henry Ernest Englander, Herman Sigmund Flint, Delos Edward Frampton, William Rex Frankel, Stanley Phillips Fraser, Stuart McMillan Freede, Henry James French, Edward Davis Gale, George Phipps Gassaway, James Scott Geldson, Norman Paul Gerhart, Ray Van Deusen Gewe, Robert Alexander Gombotz, Joseph John Goodin, Harry Allen Green, Albert Pennington Griffiths, John Robert Gross, Arthur George Guillou, Alfred Victor Hagen, Robert Christian Haines, Wilbur Fox Hall, Marcus A. Hance, Harold Vivian Haussler, Robert Walter Hofeller, Gilbert Walter Hoff, Frederick Carl Hoiles, Harry Howard House, William Carl Huggins, Thomas Jackson, Jr. Ingalls, Francis Chandler Israel, Richard Alfred Jewett, Robert Vincent Kimball, Robert Barry King, Robert Warren Krieger, Stuart Alvin Kuttler, Luther Perry Kyte, Robert McClung Langerud, Ralph Owes Laue. Eric Gilbert Lavine, Richard Allen Lawrie, Donald Gibb Lawson, William George Lebow, Myer Irwin

HOME ADDRESS Los Angeles Palo Alto Los Angeles Pasadena Redlands Los Angeles South Pasadena Inglewood Phoenix, Arizona Glendora Sierra Madre Pasadena Glendale Los Angeles San Diego Oklahoma City, Oklahoma Niagara Falls, New York Pasadena Los Angeles Los Angeles Pasadena Los Alamos San Marino South Pasadena Los Angeles Santa Barbara Beverly Hills Hollywood Riverside Burlingame Pasadena Los Angeles Los Angeles Pasadena Elgin, Minnesota Orange Eau Claire, Wisconsin Baltimore, Maryland Alhambra Glendale Portland, Oregon Glendale Cristobal, Canal Zone Los Angeles Los Angeles Huntington Park Oslo, Norway Los Angeles Los Angeles Milwaukee, Wisconsin Pasadena Los Angeles

LeGrand, Charles Croxall Lipson, Morris Longfelder, Harlowe Julius MacDonald, Donald Charles Macleish, Kenneth Gordon Maguire, Malcolm Rodney Matthew, Tyler Mayeda, Takashi McClung, Roderick Marshall McCreery, Frank Ewing McKinlay, James Robb Mellin, Waino Merrick, William Deming Merrill, Fred Elbridge Meyer, David Elmore Miller, Charles Norman Mills, Chester David Mills, Mark Muir Moran, Stephen Faulkner Morikawa, George Kiyoshi Munsen, John Robert Nicholson, David Field Norton, William Mear Ohlsson, Olof Gustaf Osborn, John Edward Paul, Carl Hutton Perry, Norman Conrad Phillips, Laurence Gail Pierpont, Robert Paterson Pinney, Edmund Joy Pond, Richard Kelley Rainwater, Leo James Rasmussen, Volney Kinne Regan, Louis John Reppert, Allen Burrows Richards, Raymond Gardner Rogers, Arnold Lawrence Root, William Arthur Rosanoff, Richard Albert Rothman, Sanford Roudebush, Bert Victor Rounsefell, John de Wolf, Jr. Rugar, Jack Ruggiero, Ralph John Schneider, Selmer Guerton Scott, David Holcomb Segerstrom, Richard John Sharples, Thomas Davy Sherwin, Allyn

NAME

Lee, Curtis Munn

Shields, Alexander McMillan, II Shultise, Quido Miles

Home Address San Diego South Pasadena Van Nuys Los Angeles Billings, Montana Santa Barbara Los Angeles Hollywood Honolulu, T. H. Winslow, Arizona Coronado Glendale Berkeley Glendale Oakland San Marino San Francisco San Diego Estes Park, Colorado Long Beach San Diego Marion, Iowa Los Angeles Beverly Hills Pasadena Pasadena Hollywood Los Angeles San Diego Ojai Seattle, Washington Los Angeles Hanford Hamburg, New York Hollywood Amarillo, Texas Exeter Los Angeles Huntington Park Rosemead Los Angeles Glendale Glendale Park City, Utah Los Angeles Beverly Hills Pasadena Sonora South Pasadena Batavia, New York San Francisco Pasadena

NAME Simonds, John Howland Smith, Oscar A., Jr. Smith, Paul Louis Smith, Philip Ernest Smith, William Davis Spotts, Ralph Hall, Jr. Steel, Collis Kaehler Stirling, Elton Bernard Streightoff, Frank Doan Strong, Herbert Davis Sullivan, Edwin Franklin Sundt, Harald Tangren, Robert Fulton Thomas, Neal Whitcomb Umeda, Shigetoki Van Deusen, George Hanchett Van Dusen, Laurence William Veenhuyzen, Paul Norman Anton Waugh, Robert Webb, Donald Thomas White, Robert William Williams, Robert Irving Winchell, Robert Winslow Womack, Kenneth Elliott, Jr. Younger, Udene Earl Zukerman, Lester Goffin

Home Address Boston, Massachusetts San Marino Pasadena Santa Ana Porterville **Beverly Hills** Butte Čity Pasadena Indianapolis, Indiana Glendale San Bernardino Oslo, Norway Colfax Los Angeles Los Angeles Battle Creek, Michigan San Diego Monterey Park Pasadena Miles City, Montana Long Beach San Juan Capistrano Beverly Hills Houston, Texas Los Angeles New York City, New York

SUMMARY

GRADUATE SCHOOL

National Research Fellows	4
Research Fellows of the Institute	15
Commonwealth Fund Fellows	2
International Exchange Fellow	1
Fellow of the John Simon Guggenheim Memorial Fund	1
International Research Fellows of the Rockefeller	
Foundation	2
Research Assistants of the Institute	22

 $\mathbf{47}$

GRADUATE STUDENTS

RESEARCH FELLOWS

Physics	50
Chemistry	25
Chemical Engineering	3
Mathematics	11
Geology	20
Biology	10
Meteorology	23
Electrical Engineering	19
Mechanical Engineering	7
Civil Engineering	12
Aeronautical Engineering	28
-	

208

UNDERGRADUATE SCHOOL

Seniors	126
Juniors	138
Sophomores	149
Freshmen	159

572

Total Number of Students 780

COURSES AND OPTIONS OF UNDERGRADUATE STUDENTS

SCIENCE COURSE	Seniors	Juniors
Physics	13	16
Chemistry	6	14
Applied Chemistry	14	16
Mathematics	1	0
Geology		5
Biology		5
Total	44	56

Engineering Course

Electrical	25	21
Civil	. 18	12
Mechanical	29	35
Aeronautical	10	14
Total	82	82

Index

Subject	Page
Abbroviations	146 247
Absorand	110, 211
Apsences	
Accounting	
Administrative Officers	1.1.1
Admission	.80, 117
Admission to Upper Classes.	83
Admission to Graduate	
Standing	117
Advanced Alternating Curre	nt
Machinery	
Advanced Calculus	168
Advanced Carculus	191
Advanced Circuit Analysis .	117 190
Advanced Degrees	111, 140
Advanced Economic Geology	
Advanced Descriptive	
Geometry	
Advanced Freehand Drawing	z211
Advanced Genetics	224
Advanced Machine Design	
Advanced Petrology	222
Advanced Physiology	226
Advanced Physiology	0.00 A
Design	ane
Design	
Advanced Problems in Theo	ret-
ical Aeronautics	
Advanced Standing	83
Advanced Surveying	192
Advanced Work in	
Engineering	201
Advanced Work in	
Hydraulic Engineering	914
Advisory Council	
Advisory Council	
Aero Ciup	
Aeronautical Engineering	
Aerodynamics	
Aerodynamics of the Airplan	ie204
Aeronautical Laboratory	70
Aeronautical Seminar	208
Aeronautics	158.204
Aid for Students	88.96
Aircraft Structures	204
Airnland Design	205
Alternating Current Apolygic	177
Alternating Gument	5Tit
Alternating Current	1-7 170
Laboratory $\ldots 175$,	117, 178
Alternating Currents	175, 177
American Petroleum Institut	te
Fellowships	136
Analysis of Earthquake Effe	ets
Upon Structures	
Analytic Geometry	168
Analytical Chemistry	182
Analytical Machanics	161
Angiont and Modioval Histor	
Ancient and Medieval Histor	y400
Animal Physiology	
Applied Chemistry	152, 191
Applied Chemistry, Research	1
Laboratory	66
Applied Geophysics	221
Applied Hydrodynamics	213
Applied Mechanics	
Applied Physics	149
Assembly	140
Assistantshine	194
Associated Student Dela	
associated student polly	

Subject 1	'age
Associates	. 29
Associates, Hall of the	• • • •
Laboratory	.111
Astronomy	.148
Astrophysics	, 165
Astronomy and Physics	100
Athenseum 74	$, 100 \\ 131$
Athletics	239
Atomic Physics	.161
Auditorium	. 71
Bachelor of Science,	0.00
Basteriology	243
Balch Graduate School of the	. 44 4
Geological Sciences	.107
Biochemistry	, 226
Biological Sciences72, 110, 154,	, 223
Biology Journal Club	.225
Biological Problems	· 996
Biophysics	.226
Blacker House	. 75
Blacker Scholarships	. 96
Board of Trustees	. 6
Books, Cost of	. 87
Bridge Laboratory of Physics	. 90
Buildings and Facilities	64
Business Economics	237
Business Law	.236
Calculus, Advanced	.168
California Instituto Associatos	.4, 0
California Tech School Paper 7	- 30 7 86
Change of Schedule	. 90
Chemical Engineering99, 157,	189
Chemical Engineering	
Chemical Laboratory	,186
Chemical Principles	184
Chemical Research 186	190
Chemistry	182
Chemistry, Applied, Laboratory	. 66
Chemistry Review	.183
Civil Engineering102, 144, 159,	192
Civil Engineering Seminar	196
Cleveland Loan Fund	. 88
College Year	. 5
Colloid and Surface	
Chemistry	186
Conditions Removed	490
Conduction of Electricity and	. 02
Gases	.181
Conformal Representation	.170
Conger Peace Prize	3, 97
Literature	990
Contemporary English and	.448
European Literature	.228
Constitution of the United	
States	.234

Subject	Page
Contents	
Corporation Finance	
Cost of Supplies and Boo	179 87
Course in Engineering	137.142
Courses in Science	138, 147
Courses, Undergraduate	
Credits	
Culbertson Hall	
Current Topics	
Debrey Hell of the	
Humanities	
Dabney House	
Damage to Property	
Daniel Guggenheim Aero	nautical
Laboratory	70, 104
Daniel Guggenheim Airsl	hip
Institute	
Daniel Guggenneim Grad	iuate 104
Dates of Examinations	5 81 84
Deans	
Debating	78, 229
Degrees	
Degrees Conferred, 1935	
Deposits	
and Fifth Vear Course	uuale 137
Descriptive Geometry	211 212
Dielectrics	
Differential Equations	
Differential Geometry	
Direct Currents	175, 176
Direct Current Laborato	ry. 175, 176
Dismissal	90
Divisions of the Institute	2
Division of the Year	5
Doctor of Philosophy,	100 100 010
Degree of	120, 123, 240
Drake Scholarshins	96
Drawing	
Dramatics	
Dynamic Meteorology	
Earthquake Effects, Stru	ctures197
Economics	
Educational Policies	61
Educational Facilities	
Elasticity Applied to	
Aeronautics	
Electric Circuits	
Electric Lighting and Po	wer 178
Electric Strength of Diele	ectrics 180
Electric Traction	
Electric Transients	
Electrical Communicatio	n
Electrical Design, Princip	ples of 181
Electrical Engineering 109	143 155 175
Electrical Laboratory	170, 100, 170
Electrical Machinery	
Electrical Measurements	
Electricity and Magnetis	$m_{1}, \dots, 160$
Electricity Sound and Li	ght159

Subject	Page
Electromagnetic Waves,	- 49
Theory of	
Elementary Blology	
Elementary French	231
Elementary German	231
Elementary Italian	
Elementary Paleontology	
Elementary Theory of Ten	nsors170
Elements of Structures	
Embryology	
Employment	88
Engine Laboratory	101
Engineering Chemistry	182
Engineering	
Conferences17	7, 194, 201
Engineering Course	137, 142
Engineering Drawing	
Engineering Geology	
Engineering Mathematical	
Physics	
Engineering Research	cc
Engineering Seminer	106
Engineering Societies	
English	
English Composition and	
Reading	
English Literature, Surve	y of228
Enrollment	
Entomology	
Entrance Examinations	
Entrance Requirements	80, 83, 117
Examinations	
5 81 83 91 9	2 125 227
Executive Council	7
Expenses	86
Experimental Embryology	
Experimental Farm, Plant	72, 111
Extra-Curricular Opportun	nities . 76
Facilities, Educational	64
Faculty	9
Faculty Committee on Stu	ident 70
Faulty Officing and Comp	mittoog
Faculty Oncers and Com	
Fellowshins and Assistant	-
ships	
Field Geology	
Fifth-Year Courses6	1, 137, 155
Financial Organization	
Fleming House	
Four-Year Courses	$\dots 61, 137$
Freehand Drawing	
French, Elementary	
Freshman Mathematics	
Freshman Prize Scholarsh	ips96
Functionals and Functiona	ul
Equations	· · · · · · . 172
Gas Engine Laboratory	
Gates Chemical Laboratory	v65
General Aeronautics	
General Botany	
General Regulations	200 QU
Genetics	

Subject Page
Geodesv and Precise Surveying 196
Geologic Illustration
Geological Research108, 219
Geological Sciences107
Geology and
Paleontology107, 153, 157, 215
Geology-Paleontology Club219
Geology of the Southwest222
Geometrical Transformations
Coometry 168 170
Geomorphology
Geophysics
Geophysics Seminar
German, Elementary231
German Literature
Grades on Degrees
Grading, Scholastic91, 123
Graduate Life
Graduate Opportunities
Graduate Standing
Graduates 1935
Graduation
Greek
Guests
Guggenheim Aeronautical
Laboratory
Hall of the Associates
Hall of the Humanities71, 116
Health
Heat Engineering199, 200, 202
Theory 164
Heating Plant
High Potential Research
Laboratory 65
Higher Mathematics for Engi-
neers and Physicists
Highway Engineering
Highway Problems
Historical Geology 915
History and Government
History of Geology
Holidays 5
Honor System 90
Honor Standing 94
Honor Students, Aid for 94
Honor Students, Committee on 94
Honors, 1955
Hospitalization Fee 86 118
House Dues 87
Hughes Loan Fund
Humanities
Humanities, Hall of the71, 116
Huntington Library and Art
Gallery
Hydraulic Engineering Research. 103
Hydraulie Machinery
Laboratory Research
Hydraulic Problems 919
Hydraulics
Hydraulics Laboratory67. 213
Hydrodynamics of a Compres-
_ sible Fluid206
Industrial Accounting

Subject	Page
Industrial Chemistry	.186
Inspection Trips	5, 189 86
Inspiration Consolidated Copper	
Company	136
Institute Associates, California	
Institute Research Fellowships	135
Intercollegiate Sports	239
Intramural Sports	239
Introduction to Higher	
Geometry	169
Introduction to Philosophy	238
Analysis	170
Introduction to Mathematical	
Physics	160
Introduction to Quantum	
Mechanics	.,162
Molecules	189
Introduction to Statistics	171
Introduction to Theory of Func	_
tions of Real Variables	169
Introduction to the Theory of	164
Introduction to Theory of	
Numbers	170
Introduction to Wave	
Mechanics	.187
Invertebrate Paleontology	, 220
Irrigation and Water Supply	. 194
Italian, Elementary	. 231
Jackson Loan Fund	. 88
Journalism	230
Kellogg Radiation Laboratory	. 97
Kerckhoff Laboratories of	
Biology	72
Kinetic Theory	.162
Kinetics of Heterogeneous	100
Kinetics of Homogeneous	. 100
Reactions	.188
Laboratories	. 64
Laboratory Studies in	010
Lapsuages	
Late Registration	. 86
Leave of Absence	. 95
Lecture Courses	. 76
Libraries	. 73
Literature of the Bible	229
Loan Funds	. 88
Machine Design	, 199
Mammalian Anatomy	. 225
Marine Station at Balboa	. 12
Masonry Structures	.195
Master of Science,	
Degree of	, 241
Materials and Processes	.198
Mathematical Analysis	
Introduction to	.170
Mathematical Logic	.173
Mathematics	, 167

Subject Page Mechanical Engineering102, 145, 156, 198 Mechanical Engineering Mechanical Laboratory...203 Mechanical Laboratory..200, 201, 202 Mechanics, Applied209 Mechanics, Molecular Physics and Heat Methods of Mathematical

 Autous of Mathematical
 173

 Physics
 173

 Million-Volt Transformer
 65

 Mineragraphy
 221

 Mineralogy
 215, 221

 Minimum Scholarship Require 92

ments 92 Modern Algebra 169 Modern Analysis 171 Modern Aspects of the Quantum Mount Wilson Observatory. 111, 136 National Research Fellowships. 136 National Youth Administration. 89 Nature of the Chemical Bond....187 Non-Metalliferous Deposits.....220 Officers of the Board of Trustees Officers and Committees of

 Officers and Committees of the Faculty
 8

 Olive Cleveland Fund.
 88

 Operational Circuit Analysis.
 181

 Optical Mineralogy
 216

 Optics
 161

 Options
 138

 Ore Deposits
 220

 Organic Chemistry
 185, 189

 Organic Chemistry, Research Conference
 191

 Organic Chemical Analysis
 189

 Paleontology
 107, 215

 Partial Differential Equations of Mathematical Physics
 174

Subject Page Physical Chemistry Laboratory .184 Physical Education79, 140, 239 Physical Examinations77, 82, 85 Electromagnetic Waves164

 Reading in French, Italian or German
 232

 Refrigeration Plants
 202

 Registration
 90, 119, 122

 Registration Fee
 83

 Reinforced Concrete
 194

 Reinstatement
 93

 Relativity
 164

 Requirements for Admission
 80

 Requirements, Scholastic
 92

 Research at the Institute
 98

Research at the Institute...... 98 Research Conferences 165, 191

 Research Conference on Physics of Solids
 165

 Research Fellowships
 135

 Research Laboratory of Applied Chemistry
 66

 Research in Biology
 225

 Research in Physics
 .98, 165, 166

 Research Manipulations
 .190

 Residence Requirement
 .122

 Ricketts House
 .75

 Room and Board, Cost of
 .87

 Roster of Students
 .247

 Schedules of Undergraduate
 .197

Research Conference on Physics Schedules of Undergraduate

Subject	Page
Seminar in American History	
and Government	234
Seminar in Biochemistry	225
Seminar in Business Economic	s.237
Seminar in Continuous Groups	1173
Seminar in Economic Geology.	221
Seminar in Electrical	
Engineering	180
Seminar in Genetics	
Seminar in invertebrate	990
Seminar in Motola	160
Seminar in Mineralogy	291
Seminar in Modern Theories	
of Integration	173
Seminar in Petrology	
Seminar in Radiation	166
Seminar in Social and	
Economic Organization	236
Seminar in Theoretical	
Physics	165
Seminar in Vertebrate	0.0.0
Cominge on X Dediction	
Seminar on A-Radiation	105
Geology	218
Senior Thesis Problem in	
Paleontology	218
Sewage Treatment Plant Desig	n.197
Sewerage	. 195
Sigma Xi	77
Sociology	238
Soil Conservation Laboratory	69
Soil Mechanics	210
Sophomore Mathematics	167
Sophomore Prize Scholarship,.	
Southarn Colifornia Dublic	163
Speaking Assn	70
Special Composition	229
Specifications and Design of	
Electric Machinery	179
Spectroscopy Laboratory	162
Spelling	230
Spring Field Trip	216
Staff of Instruction and	· · -
Research	.9,47
Statically indeterminate	100
Structures	190
Steam Laboratory	67
Strength of Materials	209
Structural Design	. 195
Structural Geology	. 217
Structure of the Atmosphere	207
Structure of Crystals	188
structures	193
Student Employment	88
Student Health Program	. 79
Students on Probation	10, 87
Student Organization	93 76
Students Boster of	247
Study and Research at the	
Institute	. 98
Subjects of Instruction	.159

Subject Page
Summer Field Geology218
Summer Reading
Surface and Colloid Chemistry 186
Survey of English Literature228
Surveying
Synoptic Meteorology207
Tau Beta Pi
Telescope 200-Inch 111
Terms
Testing Materials Laboratory 209
Text-Books, Cost of
Theoretical Aerodynamics205
Theory of Electricity and
Magnetism
Theory of Electromagnetic
Waves
Theory of Electrons
Theory of Equations
Theory of Numbers.
Introduction to
Theory of Sound163
Theory of Structures
Thermodynamics 162
Thesis
Thesis Problem in Geology218
Thesis Problem in Paleontology.218
Throop Hall
Transformer, Million-Volt
Transmission Lines
Transmission Line Problems180
Trustees, Board of 6
Tuition
Undergraduate Student Houses. 75
Undergraduate Students255
Underground Water
Investigations
Units, Explanation of124, 140 Units for Graduation 93
Upper Class Admissions
Vacations 5
Vaccination
Vacuum Tubes
Frequency Circuits
Vector Analysis
Vertebrate Anatomy225
Vertebrate Paleontology
W K Kellogg Laboratory of
Radiation
Water Power Plant Design196
Water Supply194
Water Treatment Plant Design 197
tion to 187
William G. Kerckhoff
Laboratories of the
Biological Sciences 72
х. м. с. а 78