PROFESSIONAL SUMMER SCHOOLS

(Temporarily discontinued as the Institute is now operating on a continuous basis)

REQUIREMENTS FOR THE BACHELOR'S DEGREE

To receive the Degree of Bachelor of Science (S.B.), Bachelor in Architecture (B. Arch.) or Bachelor in City Planning (B.C.P.), the student must have attended the Institute not less than one academic year, which must, in general, be that next preceding his graduation. He must have completed the required curriculum for the Class with which he will graduate unless minor substitutions are permitted. No substitution will be permitted in the First-year Program, in the Second-year Program excluding professional subjects, and in the Humanities Programs of the third and fourth years including Economic Principles Ec11. Substitution is not permitted for professional subjects in the second year and for subjects marked with an asterisk (*) in the third and fourth years unless the proposed subject has practically the same subject content, same objectives, and at least the same number of units as the subject in the curriculum. For the duration of the war, Fourth-year Professional Subjects or Graduate Subjects may, by petition, be substituted for Thesis.

The ability of the student to perform an original piece of work is considered an important feature of his degree requirements and theses are required in all course schedules. All theses and records of work done in preparation of theses are the permanent property of the Institute, and must not be published, either wholly or in part, except by authorization of the heads of the respective departments.

No degree will be conferred until all dues to the Institute are paid.

SUBJECT NUMBERING SYSTEM

Subjects are grouped and numbered according to the Department under which the instruction is given. A Course is a program of study made up of subjects selected from the several Departments, and leads to a degree in a given field of science or engineering. The arabic numerals for the subjects correspond to the Roman numerals of the Courses in the same Department, except Courses IX and XVIII.

Department	Subject Numbers
Civil and Sanitary Engineering	1·00 to 1·99
Mechanical Engineering	2·00 to 2·99
Metallurgy	3·00 to 3·99
Architecture and Planning	4·00 to 4·99
Chemistry	5·00 to 5·99
Electrical Engineering	6·00 to 6·99
Biology, Food Technology	7·00 to 7·99
Physics	8·00 to 8·99
Chemical Engineering	10·00 to 10·99
Geology	12·00 to 12·99
Naval Architecture and Marine Engineering	13·00 to 13·99
Meteorology	14·00 to 14·99
Business and Engineering Administration	15·00 to 15·99
Aeronautical Engineering	16·00 to 16·99
Building Engineering and Construction	17·00 to 17·99
Graphics	D1 to D99
Economics and Social Science	Ec1 to Ec99
English and History	E1 to E99
General Studies	G1 to G99
Languages	L1 to L99
Mathematics	M1 to M99
Military Science and Tactics	MS1 to MS99

The time given to each subject is expressed in units, one unit representing 15 hours' work. (Units in class are placed first, followed by preparation units.) The units of preparation represent the estimated time for the average student.

One unit of Recitation or Lecture credit is equivalent to one semester hour. Two units of Drawing or Laboratory credit are equivalent to one semester hour. The division between Recitation or Lecture and Drawing or Laboratory time is shown in the Tabulation of Subjects.

FIRST YEAR FOR ALL COURSES

First Term	5·01	Chemistry, General	7–4
	8·01	Physics	6–5
	D11	Engineering Drawing	6–0
	E11	English Composition	3–5
	M11	Calculus	3–6
	MS11	Military Science	3–0
			28–20

Second Term	5·02	Chemistry, General	7–4
	8·02	Physics	6–5
	D12	Descriptive Geometry	6–0
	E12	English Composition	3–5
	M12	Calculus	3–6
	MS12	Military Science	3–0
			28–20

XVII. Building Engineering and Construction Continued

OPTION 2. LIGHT CONSTRUCTION

First Term	15·41	Finance	3–6	*Second Term*	*2·373	Testing Materials Lab.	5–2
	15·61	Law of Contracts	3–6		15·82	Sales Promotion	3–6
	15·81T	Marketing & Reports	4–8		*17·40	Estim. and Job. Manage.	5–4
	*17·73	Materials	2–4		*17·56	Structural Design	7–5
		*Thesis	4			*Thesis	5
		†Humanities IV	3–5			†Humanities IV	3–5
			48				50

XVIII. MATHEMATICS

THE Institute offers exceptional opportunities for the study of mathematics, either in its theoretical aspects or as applied to scientific and engineering work.

The Course outlined is for students who desire to study more mathematics than is contained in the professional courses. It is well adapted to serve as a preparation for specializing in pure mathematics, in mathematical physics, or in engineering fields requiring proficiency in pure mathematics. The course also offers excellent opportunities for students who wish to major in mathematical statistics, applied statistics or actuarial work.

Any student who has completed satisfactorily the work of the first two years in any of the professional courses in the Institute or their equivalent, provided always that a creditable record has been obtained in mathematics and physics, may be admitted to the third year in this Course.

OPTION 1. PURE AND APPLIED MATHEMATICS

Option 1 is intended for students interested in technical applications of mathematics or a career of research and teaching. Students planning to take this option are required to take electives in science and engineering which, together with their courses in pure mathematics, constitute a well-integrated program in pure or applied mathematics.

OPTION 2. INDUSTRIAL STATISTICS

Option 2 is adapted to those preparing for industrial work where the statistical interpretation of data is important, or for the actuarial profession. Students planning to take this Option are required to take subjects in mathematics and engineering related to statistics to fulfill the elective requirements.

Both options lead to the degree of Bachelor of Science in Mathematics.

FIRST YEAR (See page 38)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	8·04	Physics	5–5
	8·03	Physics	5–5		E22	U. S. in World Hist. — Humanities II	3–5
	E21	U. S. in World Hist. — Humanities II	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		M32	Statistics, Elementary	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		Language	3–5			Language	3–5
			24–24				20–27

THIRD YEAR**

First Term	Ec11	Economic Prin. — Humanities III	3–5	*Second Term*	*M332	(2) Math. Th. of Statistics	3–6
	*M331	(2) Math. Th. of Statistics	3–6		*M62	(1) Modern Algebra	3–6
	*M731	(1) Mechanics	3–6		*M732	(1) Mechanics	3–6
	*M77	(1) Vector Analysis	3–6		*M832	Analysis	3–6
	*M831	Analysis	3–6			†Humanities III	3–5
		(1) Elective Subject	12			(1) Elective Subject	12
		(2) Elective Subjects	21			(2) Elective Subjects	21
			47				47

FOURTH YEAR

OPTION 1. PURE AND APPLIED MATHEMATICS

First Term	M571	Differential Equations	3–9	*Second Term*	M442	Diff. Geometry, Elem.	3–6
	M681	Calculus of Variations	3–9		M572	Differential Equations	3–9
		*Thesis	4			*Thesis	7
		†Humanities IV	3–5			†Humanities IV	3–5
		Elective Subject	12			Elective Subject	12
			48				48

OPTION 2. INDUSTRIAL STATISTICS

First Term	M341	Modern Statistical Th.	3–6	*Second Term*	M342	Modern Statistical Th.	3–6
		*Thesis	4			*Thesis	7
		†Humanities IV	3–5			†Humanities IV	3–5
		Elective Subjects	27			Elective Subjects	24
			48				48

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.
** Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.

Modern Languages Continued

French included in second term. Texts (subject to modification): Fraser and Squair and Carnahan, *Standard French Grammar;* Hills and Dondo, *La France;* Maupassant, *Six Contes Choisis;* Eve Curie, *Madame Curie;* one short play.

L61, L62. Intermediate French. Continuation of grammar, pronunciation, and useful conversational forms; reading of matter dealing with French geography, history, and industrial activity; some standard modern authors; reading of scientific French; individual written translations from recent scientific works.

L81, L82. Elementary Spanish. Pronunciation, elementary grammar (first term), graded reading matter. Practice in conversation, composition (second term). Texts (subject to modification): Hills, Ford, Rivera, *Brief Spanish Grammar for Colleges;* Castillo and Sparkman, *Graded Spanish Readers;* Valdes, *Los Puritanos;* Galdós, *Doña Perfecta;* the New York newspaper *La Prensa.*

L83, L84. Intermediate Spanish. Brief grammar review, conversational forms, composition and letter writing; reading of varied matter, a large part of which deals with Spanish-American countries. Texts (subject to modification): Seymour and Carnahan, *Alternate Spanish Review Grammar;* Castillo and Sparkman, *Volando por Sudamérica;* Crow, *Cuentos Hispánicos;* Quintero, *Doña Clarines.*

L91, L92. Elementary Italian. Pronunciation, elementary grammar, easy reading matter, practice in conversational phrases useful for travel. Texts (subject to modification): Russo, *Elementary Italian Grammar;* Russo, *Nel Paese del Sole;* Capocelli, *L'Italia nel Passato e nel Presente;* Wilkins and Altrocchi, *Italian Short Stories.*

For description of the following see Division of General Studies.

G581, G582. Elementary Russian.

MATHEMATICS

Subjects M1 to M99

M1. Entrance Algebra.

M3. Entrance Solid Geometry.

M4. Entrance Trigonometry.

M11. Calculus. Fundamental ideas of calculus. Differentiation and graphical representation of algebraic, trigonometric, logarithmic and exponential functions. Integration of simple algebraic and transcendental functions. Maxima and minima applications to problems in geometry and mechanics, such as determination of velocity, acceleration, area, volume and pressure. Discussion of the analytic geometry of the straight line, and the conic sections.

M112. Mathematics (College Transfer). For college transfer students who have taken calculus prior to their transfer but whose preparation is not sufficient to cover first year requirements.

M12. Calculus. Parametric representation of curves, polar coördinates. Methods of integration including approximate integration. Further applications of derivatives and integrals, including arc length, curvature, surface area, center of gravity and moment of inertia. Average values. Elementary vector analysis in the plane, vector velocity and acceleration.

M21. Calculus. Partial differentiation. Infinite series. Complex numbers. Surfaces and vectors in three-dimensional space. Dot and cross products of vectors and their applications. Multiple integration and geometrical and physical applications.

M212. Mathematics (College Transfer). For college transfer students who have taken calculus prior to their transfer but whose preparation is not sufficient to cover second year requirements.

M22. Differential Equations. Treatment of ordinary differential equations including principal types of first and second order equations, simultaneous equations, and linear equations with constant coefficients. Illustrated by numerous applications to geometry, chemistry, physics and mechanics. Phillips, *Differential Equations, Third Edition.*

M31. Differential Equations. Complex numbers, Fourier series, partial differentiation, systems of ordinary differential equations and some simple partial differential equations with applications to the long line and heat flow. Laplace Transforms. Franklin, *Differential Equations for Electrical Engineers.*

M32. Elementary Statistics. General survey of practical application of statistical methods to scientific and engineering problems, covering frequency distributions, moments, precision of measurements, correlation, tests of significance, analysis of variability and experimental design.

M331. Mathematical Theory of Statistics (B). Mathematical methods of statistics and their application to scientific and engineering data, including systems of frequency curves and moments, theory of large and small sampling simple partial and multiple correlations, contingency, statistical estimation, and analysis of variance.

M332. Mathematical Theory of Statistics (B). Statistical principles applied to design and analysis of complex experiments. Discussion of mathematical theory underlying modern experimental arrangements. Practical problems involving Latin squares and their variations, factorial design, split plot experiments, confounding and partial confounding, etc.

M341, M342. Modern Statistical Theory (B). Topics varying from year to year. Discussion of papers taken from recent journals. Solution of scientific and industrial statistical problems.

M351, M352. Advanced Calculus for Engineers (A) Vector calculus with applications to geometry, kinematics, mechanics and hydromechanics. Partial differentiation. Fourier series and complex variables with applications to differential equations. Lagrange's equations for dynamical systems and applications to vibrations, stability, and theory of structures. Franklin, *Methods of Advanced Calculus;* Karman and Biot, *Mathematical Methods in Engineering.*

M36, M37. Advanced Calculus (A). Complex variable, power series, partial differentiation, implicit functions, Gamma and Beta functions, line, surface and space integrals, vectors, ordinary differential equations, Bessel functions, partial differential equations, calculus of variations, elliptic integrals.

M381, M382. Theory of Functions (A). General subject in analysis somewhat more advanced than M36, M37. Series, infinite products, the Riemann integral, functions of a complex variable, contour integration, asymptotic expansions, Fourier series, differential equations, integral equations, and various transcendental functions of importance in the applications of mathematics. Logical derivation of the processes of analysis connected with these topics. Whittaker and Watson, *Modern Analysis.*

M441. Projective Geometry (B). Homogeneous coördinates. Point, line, and plane coördinates. Ranges and pencils. Principle of duality. Curves and surfaces of second order and of second class. Linear transformations. Projective measurement. Non-Euclidean geometry. Pentaspherical and Plücker coördinates. F. S. Woods, *Higher Geometry.*

M442. Elementary Differential Geometry (B). Plane and space curves. First and second differential form of a surface. Theorems of Meusnier and Euler. Lines of curvature, asymptotic lines, conjugate lines, geodesics. Theorems of Gauss and Codazzi. Developable surfaces, surfaces of rotation, Liouville surfaces. Differential parameters. Problems of mapping. W. C. Graustein, *Differential Geometry;* L. P. Eisenhart, *Differential Geometry.*

Mathematics Continued

M451, M452. Fourier Series and Integrals (A). Elementary theory of Fourier series and integrals as developed along modern lines. Stress on practical applications and development of the necessary analysis from the beginning.

M461. Seminar in Applied Mathematics (A). Mathematical discussion of linear and non-linear problems arising in the field of mechanics of a continuum.

M54. Mathematical Laboratory (B). Practical instruction in numerical, graphical and mechanical calculation and analysis as required in the engineering or applied mathematical sciences, numerical solution of equations; graphical methods; nomography and the construction of graphical charts; curve fitting to empirical data, approximate methods of integration, differentiation and interpolation; use and principles of construction of instruments employed in calculation, and many kindred topics. Lipka, *Graphical and Mechanical Computation.*

M551, M552. Functions of a Real Variable (A). Theory of Lebesgue's integral with applications to important topics of the theory of functions of a real variable, such as trigonometric series, Fourier integrals, almost periodic functions, etc. Content varying from one year to another, so that graduate students taking the course for successive years can have an introduction to several important chapters of the theory of functions.

M561, M562. Functions of a Complex Variable (A). Complex integration, Cauchy's theorem, zeros, Jensen's theorem, Carleman's theorem, analytic continuation, maximum-modulus theorem, conformal mapping, power-series, entire functions. Content based upon the first eight chapters of Titchmarch, *Theory of Functions.*

M571, M572. Differential Equations (A). Constant reference to the physical problems which have given rise to the field of differential equations. Various aspects of the linear differential equation including boundary value problems and representation of an arbitrary function by Sturm Liouville functions, solution of certain of the more common equations by series and integrals, and classification of equations by singular points. Relationship between integral and differential equations. Non-linear differential equations, particularly as related to physical problems, studied by topological and analytic methods. Detailed treatment of the linear partial differential equation of the second order and study of problems from potential theory, vibrations, heat flow, and other fields by methods including the integral equation and Fourier transform. Ince, *Ordinary Differential Equations;* and a text on partial differential equations.

M581, M582. Continuous Groups (A). Basic concepts of group-theory, such as group, sub-group, invariant sub-group, finite and infinitesimal transformations; one-parameter groups and their applications to differential equations and geometry; r-parameter groups, structure constants, the fundamental theorems of Lie; invariant theories associated with continuous groups; differential invariants and applications to systems of partial differential equations.

M62. Modern Algebra (B). Polynomials, determinants, linear equations, linear transformation, matrices, linear independence, introduction to groups.

M641, M642. Tensor Calculus (A). Elements of tensor algebra, followed by analysis of tensor fields, especially of those in which a metric is defined with the aid of a quadratic differential form. Applications to differential geometry, mechanics and physics.

M651, M652. Analytical Mechanics (A). Treatment of analytical dynamics of particles and rigid bodies, mainly by Lagrange's equations in generalized coördinates and Hamilton's canonical equations. Contact Transformation, Hamilton-Jacobi theory, theory of vibrations, and non-holonomic systems.

M671, M672. Partial Differential and Integral Equations (A). Designed to show how various types of physical problems lead to partial differential equations and to integral equations; and existing technique for solving such equations. Partial differential equations, Fourier technique, various types of harmonics and special orthogonal functions, and the Fourier integral. Treatment of equations which arise in potential theory, heat flow, wave propagation, etc. Integral equations showing how such equations arise in different types of physical problems. Available methods for solving such equations, together with the various series, solutions, characteristic functions, etc. The Laplace transformation. Integral equation methods contrasted with differential equation methods.

M681. Calculus of Variations (A). Extension of theory of maxima and minima as begun in calculus. Determination of functions, curves or surfaces with given maximum or minimum properties. Applications to geometry and physics; geodesics, minimal surfaces, isoperimetric properties of circle and sphere, Fermat's principle of least time (optics), Hamilton's principle, catenary, brachistochrone. Bolza, *Lectures on the Calculus of Variations;* Bliss, *Calculus of Variations;* Goursat, *Cours d'Analyse, vol. 2, chapter XXIII.*

M691, M692. Characteristic Value Problems (A). Linear algebra, orthogonal functions, linear integral equations; characteristic value problems of mathematical physics; applications of the calculus of variations; special functions defined by characteristic value problems. Courant-Hilbert, *Methoden der Mathematischen Physik.*

M71, M72. Mathematics. Graphical and mechanical computation, review of algebra, trigonometry, analytic geometry, calculus. Differential equations, advanced calculus, elements of vector analysis. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

M73. Review of Mathematics. Review of college algebra, trigonometry, elementary calculus, differential equations. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

M731, M732. Mechanics (B). Statics; point kinematics with applications to linkwork and mechanism; polar diagrams of velocity and acceleration; kinematics and dynamics of rigid bodies in three dimensions; dynamics of mechanisms; impact, theory of the gyroscope, with applications; Lagrange's equations; Hamilton's principle; theory of vibrations, with applications to engineering problems.

M76. Theory of Probability (A). Permutations and combinations. Elementary principles of theory of probabilities. Bernoulli's Theorem. Bayes' Theorem. Distributive functions and continuous variables. Averages. Curve fitting. H. Levy and L. Roth, *Elements of Probability;* T. C. Fry, *Probability and Its Engineering Uses.*

M77. Vector Analysis (B). Treatment of vector functions and operations required in theoretical work on electricity. Phillips, *Vector Analysis.*

M791, M792. Theoretical and Applied Elasticity (A). Analysis of stress and strain in three dimensions. Stress-strain relations. Minimum principles in elasticity, their theory and application to the approximate solution of boundary value problems. Theory of bending and torsion of bars. Theory of plane stress and strain, Airy's stress function, use of elements of complex variable theory. Bending of flat plates. Bending and stretching of thin shells. Elastic stability theory. Elements of the finite deformation theory of elasticity.

M831, M832. Analysis (B). Advanced calculus for those already familiar with elementary technique and desiring some knowledge of the logical development of calculus as a mathematical science. Real and complex number system, limits, continuity, convergence, series, integration, theory of functions of real and complex variables. Franklin, *A Treatise on Advanced Calculus.*

M90. Mathematical Reading (A). Reading of advanced mathematical treatises under the supervision of some member of the department. Choice of treatise and allotment of time according to individual cases. For graduate students finding it desirable to do advanced work not provided for in the regular subjects. Open to undergraduates only under exceptional circumstances.

For description of the following see Division of General Studies.

G8. History of Philosophy.