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# Bulletin of Yale University

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1974-1975

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ADMISSION TO ADVANCED STANDING BY TRANSFER

A limited number of well-qualified transfer students (the precise number depending on current vacancies) enter Yale College each year as members of the Sophomore or Junior class. Admission by transfer is contingent upon the high quality of a student's previous high school and college records together with an evaluation of his reasons for wanting to attend Yale. Serious consideration can be given only to those applicants whose college records are of high quality. No transfer applications to the Senior class are accepted since the College requires two full years of residence in order to be eligible for the bachelor's degree.

Up to two years' credit will be granted toward a Yale College degree for quality work completed during full-time study at an accredited college or university, provided the courses completed were similar in content to those offered in Yale College. Students who will have completed less than a full year of academic work at another college by September should request regular application forms for admission to the Freshman class, but no student may relinquish academic credits in order to qualify for consideration for the Freshman class.

Applications for transfer admission are due prior to March 15. Decisions of the Admissions Committee will be reported prior to July 1.

The transfer application consists of: (1) formal application in transfer plus a \$20 non-refundable application fee; (2) official college transcript; (3) recommendation forms completed by a Dean and two professors; (4) secondary-school record and recommendation; (5) Scholastic Aptitude Test scores. A personal interview is not required.

COURSES OF STUDY\*

Since 1701 Yale College has offered courses of study leading to the bachelor's degree. A course is simply a group of students examining a particular subject under the direction of someone who has studied it before. Yale College today offers more than 1,400 term courses. A student working for a bachelor's degree ordinarily takes four or five in a term and receives a degree after eight terms.

Just as important as the courses a student takes is the relationship that these courses bear to each other. Unless they both broaden the student's understanding in several areas and deepen it in one or two.

\*The bulletin Yale College Programs of Study lists the individual courses and hours of subjects of instruction open to undergraduates.

T 8 terms implies  
Semesters

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1974-75

he may emerge with a collection of miscellaneous information but no wiser than when he entered. Yale College insists not only that students perform satisfactorily in a given number of courses but also that they follow a rational program of study which will ensure that breadth of distribution is achieved as well as mastery of a particular study or group of studies. There are more than sixty majors currently offered.

FRESHMAN AND SOPHOMORE YEARS

Much of the lasting benefit of undergraduate study at Yale will depend on careful planning of the student's program of study. It is important here to seek aid and counsel from advisers. Freshmen in particular should seek help from resident Freshman counselors, the faculty program advisers assigned to them from the fellowships of the residential colleges, their College Deans, and placement officers and directors of undergraduate studies in the various departments and programs in Yale College. Even with such assistance, however, it is probably impossible, and in fact it would be imprudent, for a student to map out at the beginning of Freshman year a firm schedule of studies for the next eight terms. Yet it is important to think ahead, and to keep certain principles and requirements in mind during the first two years of college.

One of the distinguishing features of a liberal education is that it has no single definition. Yale consequently does not prescribe any specific course to be taken by a student, but instead urges each undergraduate to design for himself his own program of study, suited to his particular needs and interests, from the multitude of courses available to college students in a university.

But it is also true of a liberal education that it is neither too narrowly focused nor too diffuse. Yale College has always, as a matter of institutional policy, stood behind the principle of distribution in studies as strongly as it has supported the principle of concentration. Yale thus requires each student in his later years in college to choose an area of concentration in one of the major programs, whether departmental or special. Yale also desires that the student's course of study be characterized, particularly in the earlier years, by a reasonable diversity of subject matter and approach. The Faculty of Yale College has therefore formally declared its support of the principles embodied in the Distributional Guidelines given below. In addition, all undergraduates must fulfill the following Distributional Requirements, which constitute the only specific rules limiting the selection of courses outside a student's major program:

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# Bulletin of Yale University

Series 70  
Number 11  
15 August 1974

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**Yale College  
Programs of Study**  
Fall & Spring Terms  
1974-75

## Bulletin of Yale University

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Issued seventeen times a year in January, April, May, June, July, August,  
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*Managing Editor:* Henry Chauncey, Jr. *Editor:* D. E. Clingan  
*Editorial Office:* 105 Wall Street, New Haven, Connecticut  
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2. Students with some experience in German whose preparation seems insufficient for a second-year college course will be placed in *German 18*. Most students with credit for two years of secondary-school German are eligible for *German 23*.

3. Students with three years of secondary-school German or with indications of high aptitude normally will be placed in *German 32*. Those with a special interest in reading techniques may take *German 30a* and *30b*.

4. Students with more than three years of secondary-school German and/or with above-average scores on the placement test on September 4 will normally be eligible to enter any advanced course at the level of 40 or above.

5. Students who have acquired a knowledge of German outside of formal training should get in touch with the Director of Undergraduate Studies for a personal interview, to be followed by provisional placement in the appropriate course.

All questions about placement may be addressed to the Director of Undergraduate Studies, Thomas P. Saine, 105 WLH.

#### HISTORY

Unless otherwise indicated in a particular course description, all courses in history are open to all students in Yale College, including Freshmen. Questions about offerings in history may be addressed to the departmental advisers listed under "History" in CHAPTER III.

#### MATHEMATICS

As in the case of foreign languages, it is a frequent and normal occurrence for a student to change the level of his course in mathematics during the first half of the fall term. The department of Mathematics prepares a preliminary placement list of members of the Freshman class on the basis of their secondary-school records and other matriculation data, and circulates the list to the residential college deans and to faculty advisers in mathematics and in related fields. It is also posted in the department of Mathematics at 218 LOM. These placements are tentative and often based on incomplete information; they are subject to revision in light of further information on the student's background, including his experience in mathematics courses at Yale during the early weeks of the term.

Students intending to take Mathematics 11a, 12a, 15a, or 20a must register for sections in LOM on Wednesday or Thursday, September 4 or 5.

The courses discussed below are those which might normally be

considered by a Freshman for the fall term. Occasionally a Freshman may have a background in mathematics which prepares him for work in more advanced courses than these, and such a student should arrange for an interview with the appropriate departmental adviser listed in the introductory portion of the section on Mathematics in CHAPTER III.

1. *Mathematics 11a* is an introduction to calculus, with attention to pre-calculus topics as needed. It is intended for students whose achievements or background in pre-calculus subjects is less than what is expected for Mathematics 12a. Preliminary placement will be made on the basis of the C.E.E.B. Achievement Test in mathematics: a score (Level I or Level II) of 650 or above indicates placement in Mathematics 12a; otherwise Mathematics 11a should be chosen. Students in doubt about their placement should discuss it with one of the departmental advisers listed under "Mathematics" in CHAPTER III, or with an instructor in Mathematics 11a or 12a.

2. *Mathematics 12a* is a course in introductory calculus for students with little or no background in calculus, but with more preparation than is expected for 11a. Mathematics 12a is the principal introductory course in calculus and usually has an enrollment at least twice that of 11a. For placement criteria for Mathematics 12a, see above, under 11a. Students with Advanced Placement Test scores of 3 or above (either AB or BC) should rule out Mathematics 12a, and many with scores of 2 will find Mathematics 15a a better choice than 12a.

3. *Mathematics 15a* is the second term of the sequence Mathematics 12a, 15b. It is the same as Mathematics 15b and is offered in the fall term to students with scores of at least 2 on the AB or BC Mathematics Advanced Placement Test, or the equivalent. Freshmen with Advanced Placement Test scores of BC 4 or 5, or AB 5, should take a higher-level course (Mathematics 20a or above). Freshmen who have had some calculus in high school, but who did not take the Advanced Placement Test, may be eligible for this course or for a more advanced one. Consult the departmental advisers listed under "Mathematics" in CHAPTER III, or the Director of Undergraduate Studies, James Lepowsky, 221 LOM.

4. *Mathematics 20a* is the third term of the basic calculus sequence (12a, 15b, 20a), and covers material on vectorial geometry and algebra and the calculus of functions of two and three variables. Placement in this course normally requires Advanced Placement Test scores of at least AB 4 or BC 3.

5. *Mathematics 22a*, a course in linear algebra, is logically almost self-contained. However, the course requires the prior study of a



year of calculus and some acquaintance with vectorial analytic geometry. The department will not itself place any student in this course, but Freshmen with strong backgrounds (a score of 4 or 5 on either Advanced Placement Test) may elect it.

6. *Mathematics 27* is a demanding course, intended mainly for mathematics majors and assuming command of techniques and theory of calculus of functions of one variable. Interested students with Advanced Placement Test scores of 5 (AB or BC) are invited to consult the instructor, whose written permission is needed for enrollment.

#### MUSIC

1. A student may elect courses in music numbered 10 through 19 without having had any previous experience in music.

2. Students who have achieved a score of at least 3 on the Advanced Placement Test may elect courses in music numbered 20 through 29. Other students who may wish to elect a course in this range must demonstrate a reading knowledge of musical notation to the instructor at the first meeting of the course.

3. For entrance to *Music 30*, the student should take a music theory placement test on Thursday, September 5, at 7 P.M. in 115 W.L.H. Those who do not achieve a satisfactory result on this test will be placed in *Music 17b*, a one-term accelerated section of *Music 12*, Introduction to Music Theory.

4. Students desiring to study music performance, whether for credit or not, should apply for an audition to the School of Music, Stoeckel Hall, 96 Wall St., by September 5. Please note that a student may offer no more than a total of four term course credits toward the requirements for the bachelor's degree for work done in professional schools of the University.

#### PHYSICS

There are four different physics sequences regularly open to Freshmen. It should be noted that placement in some physics courses depends on the student's preparation in mathematics or on concomitant enrollment in an appropriate course in mathematics.

1. *Physics 12a* and *b* is intended for students with little or no previous experience in physics who do not plan a major in the natural sciences. There is no mathematics requirement.

2. *Physics 13* is a two-term course for students with some background in physics or mathematics who do not wish to take the sequence of *Physics 14a, 15b, 23a*. Students interested in the medical or biological sciences generally take *Physics 13*.

3. *Physics 14a, 15b, 23a* is considered the standard three-term sequence for students planning to major in the physical sciences.

4. *Physics 25*, a two-term course, is an intensive, mathematically accelerated course for students with a strong preparation in physics and mathematics.

The following table compares the possible combinations of lecture and laboratory sequences with respect to the physics requirement for the medical school, acceptability for the B.A. or B.S. major in physics, and the minimum level of mathematics to be achieved concurrently.

Sequence	Mathematics to be taken concurrently	Meets medical school requirement	Acceptable for physics major
without a laboratory	none	no	no
with 12L or 13L	none	yes	no
with any laboratory	12a, 15b	yes	B.A.
15b, 23a with 12L or 13L	12a, 15b, 20a	yes	B.A.
15b, 23a with 23Lb,a	12a, 15b, 20a	yes	B.A., B.S.
with 12L or 13L	20a, 22b	yes	B.A.
with 23La,b	20a, 22b	yes	B.A., B.S., M.S.

Physics courses are arranged so that changes from one sequence to another can be effected during most of the first term. Questions about placement in physics may be addressed to the Director of Undergraduate Studies, Peter D. M. Parker, 35 SPL.

#### RUSSIAN

1. Students with no previous experience of the language may begin either in *Russian 15* or in 25. *Russian 15* meets five hours a week, *Russian 25*, an intensive course carrying double credit, meets nine hours a week. The department has found *Russian 25* to be a very successful course and recommends it to students with good language aptitude.

2. *Russian 25* is followed by *Russian 30*. *Russian 15* is followed by *Russian 22* (a double course) or by 22 which is in turn followed by *Russian 30*. The department recommends in descending order of preference the following three sequences leading to advanced courses in the Russian language or in literature:

- Russian 25* and 30.
- Russian 15* and 35.
- Russian 15, 22, and 30.*

3. Placement in *Russian 22, 30, 35, or 40* is by individual consultation with the Placement Officer in Russian, Konstantin D. Petrov; all students wishing advanced placement in Russian must



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*Literature 84a/German 84a (35070), Sociology and Literature.* Jeffrey L. Sammons. I(o)

T, Th, 1-2.15.

For description see under German.

★*Literature 84b (49413), Defenses of Poetry in Renaissance Literary Theory.* Margaret W. Ferguson. I(o)

W, 1.30-3.20.

A study of several theoretical problems, including the attempt to define a "national" literature, the defense of vernacular literature, the debate between philosophy and rhetoric. Readings from Cicero, Horace, Dante, Speroni, Joachim du Bellay, Ascham, and Sidney. A reading knowledge of French is required. *Preference given to Junior Literature majors.* (RP)

★*Literature 85a/★French 90a (32280), Ideas and the Art of Persuasion.* William R. Carlson. I(o)

M, W, 1.30-3.

For description see under French.

*Literature 85b/Classical Civilization 24b (16130), The Ancient Epic.* David B. Claus. I(o)

T, Th, 10-11.15.

For description see under Classics.

★*Literature 86/★Russian 62 (71940), Readings in Russian History.* Rurik Dudin. I(o)

M, W, F, 12.30-1.20.

For description see under Russian.

★*Literature 90 (49425), The Senior Colloquium.* Peter P. Brooks, James M. Holquist, Margaret W. Ferguson, Walter L. Reed. I(o)

Hours to be arranged.

The topic for 1974-75 is The Nature of Metaphor.

## MATHEMATICS

M

THE major in mathematics normally consists of ten term courses in mathematics numbered 22 or higher. Each student is expected to take either Mathematics 27 or 22a, 47a. He is also expected to take at least two term courses in each of three of the following categories: analysis (27, 30-39, and 47a); statistics and applied mathematics (40-49, except 47a); algebra and number theory (22a or b, 50-59); geometry and topology (60-69); logic and foundations (70-79). All mathematics majors are urged to take at least one of the following: Computer Science 21a, 43b, or 46a, which may be counted as a term course in applied mathematics. In some instances permission may be granted to take additional required term courses in other departments (e.g., Computer Science, Engineering and Applied



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Science, History of Science and Medicine, Philosophy, Physics, Statistics).

A candidate for the B.S. degree must take, in addition to the ten term courses required for the major in mathematics, at least two advanced term courses in the physical sciences, to be chosen with the approval of the Director of Undergraduate Studies, James Lepowsky.

Any student interested in mathematical research as a career is urged to take Mathematics 27, 31a, 32b, 36b, 50a, and 58b. A sample program in mathematics for such a student might consist of these courses plus three from Mathematics 64a, 66b, 70a, and 71b. Students with more interest in teaching mathematics or in applications of mathematics should seriously consider Mathematics 22a or b and 47a. A program for such a student might consist of Mathematics 22a, 36b, 41a or b, 42b, 46a, 47a, 48b, 52a, 50a or 64a, and 70a or 71b.

*The Intensive Major.* Candidates for a degree with an Intensive Major in mathematics are expected to include at least two terms of graduate course work, or of equivalent independent study, in their programs. Familiarity with the material of the following courses should be considered prerequisite to graduate courses in the respective categories: *Algebra*: two courses in the 50s. *Analysis*: Mathematics 27, 31a, 32b, 36b, 46a. *Geometry and Topology*: Mathematics 47a, 50a, 64a. *Logic and Foundations*: Mathematics 70a, 71b.

A student majoring in mathematics may, with the permission of the Director of Undergraduate Studies, write a Senior essay. He must submit a statement in writing from the member of the department who is to supervise the work.

The following members of the department may be consulted by students through their residential college affiliation:

BK, Yum-Tong Siu	MC, George B. Seligman
BR, Ronnie Lee	PC, George D. Mostow
CC, Nathan Jacobson	SY, Robert H. Szczarba
DC, Andrew Sommese	SM, Shizuo Kakutani
TD, Lawrence J. Corwin	ES, Angus J. Macintyre
JE, Tsuneo Tamagawa	TC, Walter Feit

### THE MASTER'S DEGREE PROGRAM

Students who, by the end of their Senior year, complete the requirements of the department for the M.A. in mathematics will be eligible to receive this degree at their Senior commencement. Required are: (1) eight term courses numbered 100 or higher, most of which must be completed with grades of High Pass or better; (2) a



reading knowledge of mathematical literature in a foreign language of importance for mathematical research (normally French, German, or Russian); (3) satisfactory performance on a general oral examination.

*The master's program is in no sense a substitute for the B.A. or B.S. program;* rather, it is designed to accommodate a very few exceptional students who, by means of accelerated or independent study, can satisfy the department as to their command of the content of the normal undergraduate program. Candidates must submit to the Director of Undergraduate Studies, during spring term of Sophomore year, a proposal which foresees this level of achievement by the end of Junior year. Their status and progress will be reviewed before they are permitted to continue in the program in Senior year.

At least two terms of graduate work are to be taken in the Junior year (normally courses in algebra or analysis will be the first graduate courses taken). The general oral examination covers a list of topics available from the Director of Graduate Studies, and will be accepted in lieu of the Senior departmental examination. Details concerning the requirements for the master's degree may be obtained from the Director of Graduate Studies.

#### PLACEMENT IN COURSES

Qualified Freshmen and Sophomores may, *with the permission of the instructor*, take any of the courses numbered 27 or above.

Freshmen taking calculus are normally placed in Mathematics 11a, 12a, 15a, or 20a, according to their College Board or Advanced Placement Test scores. Any interested Freshman who is placed in Mathematics 20a may take 22a instead. It is expected that any Freshman applying for advanced placement (i.e., placement in 15a or higher) will have taken the Advanced Placement Test, although it is recognized that some qualified students will not have done so. Students not given advanced placement are tentatively placed in Mathematics 11a or 12a according to their school records and test scores. All placement is subject to appeal and review during the term.

A section of Mathematics 14a (with the same content as that of 14b) will be offered, if enough students who have completed 11a indicate their interest to James Lepowsky before the beginning of classes.

The material covered in Mathematics 27 is approximately that covered in 22a (or b) and 47a, but 27 emphasizes mathematical rigor, while 22a and 47a dwell more on applications. Students who take Mathematics 27 should have a strong interest in abstract math-

ematics. Normally, students should not combine the courses 22a-47a with 27. Students who wish credit for such a mixed package of courses must get approval from the Director of Undergraduate Studies.

Both Mathematics 11a and 12a are first courses in calculus. A student may obtain credit for only one of them. Mathematics 14a and 15a are second courses in calculus. Again, only one of them may be taken for credit.

\**Mathematics E.C. I* (49640), *Mathematical Analysis*. Michael P. Anderson. IV(o)

Hours to be arranged, bc.

The purpose is to provide an introduction to modern mathematics to a small group of prospective mathematics majors. The course develops and applies concepts from calculus, differential geometry, and topology, using the study of two-dimensional surfaces as a unifying point. Assignments include challenging, non-routine problems designed to develop essential mathematical skills and to further the student's grasp of the material.

Mathematics 27 must be taken concurrently. Candidates for Early Concentration are expected to have preparation in mathematics, particularly in calculus, enabling them to earn a score of 5 on the BC Advanced Placement Test in Mathematics and entitling them to admission to Mathematics 27 as Freshmen.

*Mathematics 11a, Introduction to Calculus*. Charles E. Rickart and staff. IV(69)

11a-1 (49720). M, W, F, 8.30-9.20.

11a-2 (49721). M, W, F, 10.30-11.20.

11a-3 (49722). T, Th, 10-11.15.

11a-4 (49723). T, Th, 10-11.15.

Fundamentals of calculus of functions of one variable, with discussion of elementary functions and plane analytic geometry as needed.

*Mathematics 12a, Calculus of Functions of One Variable I*. George B. Seligman and staff. IV(69)

12a-1 (49800). M, W, F, 8.30-9.20.

12a-2 (49801). M, W, F, 10.30-11.20.

12a-3 (49802). M, W, F, 11.30-12.20.

12a-4 (49803). T, Th, 8.30-9.45.

12a-5 (49804). T, Th, 10-11.15.

12a-6 (49805). T, Th, 10-11.15.

12a-7 (49806). T, Th, 11.30-12.45.

12a-8 (49807). T, Th, 11.30-12.45.

Limits of sequences and of functions of one real variable. Differentiation of elementary functions with applications. The definite integral and the fundamental theorem of calculus, with applications. Section 8 is taught by a member of the faculty in E.&A.S., and gives greater emphasis to applications.

*Mathematics 12b* (49840), *Calculus of Functions of One Variable I*.

IV(35)

M, W, F, 12.30-1.20.

The content of this course is identical to that of *Mathematics 12a*, although it may be supplemented by a second section treating the material of *Mathematics 11a* if enrollment justifies it.

*Mathematics 13b* (49880), *Introduction to Finite Mathematics*. George B. Seligman.

IV(69)

T, Th, 11.30-12.45.

Combinatorial theory of sets and Boolean algebra of subsets and propositions. Additional topics from among finite probability, matrices, graph theory, and theory of games. *After Mathematics 11a or the equivalent, or by permission.*

*Mathematics 14a* (49910), *Topics in Calculus*.

IV(o)

Hours to be arranged.

Content the same as that of *Mathematics 14b*. *After Mathematics 11a, or the equivalent.*

*Mathematics 14b*, *Topics in Calculus*. Charles E. Rickart and staff.

IV(69)

14b-1 (49920). M, W, F, 8.30-9.20.

14b-2 (49921). M, W, F, 10.30-11.20.

14b-3 (49922). T, Th, 10-11.15.

14b-4 (49923). T, Th, 11.30-12.45.

A continuation of *Mathematics 11a*. Change of variable in integrals, integration by parts, polar coordinates, improper integrals. Taylor's theorem. Rudiments of calculus of functions of several variables, with applications. *After Mathematics 11a, or the equivalent.*

*Mathematics 15a*, *Calculus of Functions of One Variable II*. George D. Mostow and staff.

IV(69)

15a-1 (49960). M, W, F, 8.30-9.20.

15a-2 (49961). M, W, F, 10.30-11.20.

15a-3 (49962). T, Th, 8.30-9.45.

15a-4 (49963). T, Th, 10-11.15.

15a-5 (49964). T, Th, 10-11.15.

15a-6 (49965). T, Th, 11.30-12.45.

15a-7 (49966). T, Th, 11.30-12.45.

A continuation of *Mathematics 12b*. Techniques of integration. Mean-value theorems. Further physical and geometrical applications of calculus. Polar coordinates, polynomial approximations, improper integrals and infinite series, especially power series. Study of certain differential equations. *After Mathematics 12b; open to Freshmen with some preparation in calculus.* Sections 1 and 7 are taught by members of the E.&A.S. faculty and give greater emphasis to applications.

*Mathematics 15b*, *Calculus of Functions of One Variable II*. Roger E. Howe and staff.

IV(69)

15b-1 (50000). M, W, F, 8.30-9.20.

15b-2 (50001). M, W, F, 10.30-11.20.

15b-3 (50002). M, W, F, 11.30-12.20.

15b-4 (50003). T, Th, 8.30-9.45.

15b-5 (50004). T, Th, 10-11.15.

15b-6 (50005). T, Th, 10-11.15.

15b-7 (50006). T, Th, 11.30-12.45.

The content of 15b is similar to that of 15a. *After Mathematics 12a or the equivalent.* Section 7 is taught by a member of the E.&A.S. faculty and gives greater emphasis to applications.

*Mathematics 20a*, *Calculus of Functions of Several Variables*. Serge Lang and staff.

IV(69)

20a-1 (50040). M, W, F, 8.30-9.20.

20a-2 (50041). M, W, F, 9.30-10.20.

20a-3 (50042). M, W, F, 10.30-11.20.

20a-4 (50043). T, Th, 8.30-9.20.

20a-5 (50044). T, Th, 10-11.15.

20a-6 (50045). T, Th, 10-11.15.

20a-7 (50046). T, Th, 11.30-12.45.

Analytic geometry in three dimensions, using vectors. Real-valued functions of two and three variables, gradient and directional derivative, level curves and surfaces, maxima and minima. Parametrized curves in space, motion in space, line integrals; applications. Multiple integrals, with applications. *After Mathematics 15b or by permission.* Section 6 is taught by a member of the E.&A.S. faculty and gives greater emphasis to applications. (RP)

*Mathematics 20b*, *Calculus of Functions of Several Variables*. Howard Garland and staff.

IV(69)

20b-1 (50080). M, W, F, 8.30-9.20.

20b-2 (50081). M, W, F, 10.30-11.20.

20b-3 (50082). T, Th, 8.30-9.45.

20b-4 (50083). T, Th, 10-11.15.

20b-5 (50084). T, Th, 11.30-12.45.

The content of 20b is similar to that of 20a. *After Mathematics 15a or the equivalent.* Section 5 is taught by a member of the E.&A.S. faculty and gives greater emphasis to applications. (RP)

*Mathematics 22a*, *Linear Algebra and Analytic Geometry*. Howard Garland.

IV(24)

*Lect.* (50157). T, Th, 11.30-12.45.*Discussion*, 1 (50160). F, 8.30-9.20.

2 (50161). M, 12.30-1.20.

Vectors and analytic geometry in the plane and space; extensions of the basic notions to real and complex  $n$ -space and to abstract vector spaces. Linear equations and determinants, with geometrical interpretations. Algebra of matrices and linear transformations, especially orthogonal and symmetric transformations; quadratic forms and principal axes; characteristic roots and vectors. (RP)



*Mathematics 22b, Linear Algebra and Analytic Geometry.* Tsuneo Tamagawa and staff. IV(69)

*Lect., A* (50237). M, W, F, 10.30-11.20.

*Discussion, 1* (50240). Th, 8.55-9.45.

2 (50241). Th, 11.30-12.20.

*Lect., B* (50317). T, Th, 8.30-9.45.

*Discussion, 3* (50320). F, 8.30-9.20.

4 (50321). M, 12.30-1.20.

*Lect., C* (50395). T, Th, 10-11.15.

*Discussion, 5* (50400). F, 9.30-10.20.

6 (50401). M, 1.30-2.20.

(Students must enroll in a discussion section assigned to their lecture.)

The content of this course is identical to that of Mathematics 22a. (RP)

★*Mathematics 27, Vector Calculus and Linear Algebra I.* Robert H. Szczarba. IV(33)

*Lect.* (50463). M, W, F, 10.30-11.20.

*Rec., 1* (50464). T, 8.55-9.45.

2 (50465). T, 11.30-12.20.

This course gives a careful study of the calculus of functions of several variables, combined with linear algebra. Topics such as metric spaces and topology are developed as needed. *After Mathematics 20b or by permission.* (RP)

★*Mathematics 31a* (50560), *Mathematical Analysis I.* William G. Dwyer. T, Th, 1-2.15. IV(26)

A systematic treatment of metric spaces, followed by applications to differential equations. Hilbert and Banach spaces. Fourier series. *After Mathematics 27 or with permission of the instructor.* (RP)

★*Mathematics 32b* (50600), *Mathematical Analysis II.* Andrew Sommese. T, Th, 1-2.15. IV(26)

Topics include Sturm-Liouville theory, the spectral theorem for compact operators, eigenfunction expansion theory, special functions, and the Dirichlet problem. *After Mathematics 31a.* (RP)

*Mathematics 36b* (50650), *Functions of a Complex Variable.* Asger H. Aaboe. IV(23)

T, Th, 10-11.15.

The complex plane. Topological notions. Differentiability. Cauchy's theorem and formulas. Taylor and Laurent series. Analytic continuation. Normal families. Entire functions and meromorphic functions. Conformal mappings. *After Mathematics 31a or 47a or by permission.* (RP)

★*Mathematics 38a* (50680), *Measure Theory and Integration.* Shizuo Kakutani. IV(0)

T, Th, 11.30-12.45.

Introduction to Borel and Lebesgue measure and integration in  $n$  dimensions, relation to Riemann integral, convergence theorems, regularity,  $L^p$  spaces,  $L^2$  theory of Fourier series. *After Mathematics 32b or by permission.* (RP)

★*Mathematics 39b* (50720), *Introduction to Functional Analysis.* Shizuo Kakutani. IV(24)

T, Th, 11.30-12.45.

Hilbert, normed, and Banach spaces; geometry of Hilbert space, Riesz-Fischer theorem; dual space; Hahn-Banach theorem; Riesz representation theorems; linear operators; Baire category theorem; uniform boundedness, open mapping, and closed graph theorems. *After Mathematics 38a or by permission.* (RP)

*Mathematics 41a/Statistics 41a* (75080), *Probability and Its Applications.* Barry H. Margolin. IV(32)

M, W, F, 9.30-10.20.

For description see under Statistics.

*Mathematics 41b/Statistics 41b* (75090), *Probability and Its Applications.* Francis J. Anscombe. IV(32)

M, W, F, 9.30-10.20.

The content of this course is similar to that of Mathematics 41a. (RP)

*Mathematics 42b/Statistics 42b* (75110), *Theory of Statistics.* Robb J. Muirhead. IV(32)

M, W, F, 9.30-10.20.

For description see under Statistics.

*Mathematics 46a* (50880), *Elements of the Theory of Differential Equations.* Lawrence J. Corwin. IV(33)

M, W, F, 10.30-11.20.

A study of ordinary differential equations, concerned with formal methods of solution, series solutions, approximate solutions, existence and uniqueness theorems, and systems of linear differential equations. *After Mathematics 20a or the equivalent; ideally after Mathematics 22a or b.* (RP)

*Mathematics 46b* (50890), *Elements of the Theory of Differential Equations.* Yoav Benyamini. IV(26)

T, Th, 1-2.15.

The content of this course is similar to that of Mathematics 46a. *Prerequisite: the same as that for Mathematics 46a.* (RP)

★*Mathematics 47a* (50900), *Vector Analysis.* William S. Massey. IV(33)

M, W, F, 10.30-11.20.

Calculus of functions of several variables, using vector and matrix methods. Implicit and inverse mappings. Transformation of coordinates. Theorems of Green, Gauss, and Stokes. Potential theory, with physical and geometrical applications. *After Mathematics 20a, 22b, or the equivalent.* (RP)

*Mathematics 48b* (50920), *Topics in Advanced Calculus.* Yum-Tong Siu. IV(23)

T, Th, 10-11.15.

Fourier series and integrals, boundary value problems, introduction to the calculus of variations and to integral equations. *After Mathematics 20a, 22b, or the equivalent; preferably after Mathematics 46a.* (RP)

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\**Mathematics* 50a (50960), *An Introduction to Abstract Algebra*. Tsuneo Tamagawa. IV(36)

M, W, F, 1.30-2.20.

Group theory. Rings, with emphasis on integral domains and polynomial rings; modules over Euclidean domains; applications to linear algebra. *After Mathematics* 22a or b, or the equivalent. (RP)

*Mathematics* 52a (50970), *Number Theory*. Walter Feit. IV(33)

M, W, F, 10.30-11.20.

An introduction which includes prime numbers, congruences, arithmetical functions, continued fractions, Diophantine equations, quadratic and cyclotomic fields, and the geometry of numbers. *After Mathematics* 15a or the equivalent. (RP)

*Mathematics* 53b (50975), *Theory of Finite Groups*. Gerald J. Janusz. IV(26)

T, Th, 1-2.15.

Elementary properties of nilpotent, solvable, and selected simple finite groups. *After Mathematics* 50a. (RP)

\**Mathematics* 58b (51000), *Fields and Galois Theory*. Nathan Jacobson. IV(36)

M, W, F, 1.30-2.20.

The theory of fields and Galois theory, including finite fields, solvability of equations by radicals, and the fundamental theorem of algebra. *After Mathematics* 50a. (RP)

[*Mathematics* 62b, *Geometric Algebra*.]

\**Mathematics* 64a (51080), *General Topology*. Frank S. Quinn. IV(34)

M, W, F, 11.30-12.20.

Fundamental topological properties of Euclidean space; an introduction to the postulational approach to abstract topological spaces. *After Mathematics* 27 or 31a. (RP)

[*Mathematics* 65b, *Combinatorial Topology*.]

*Mathematics* 66b (51120), *Differential Geometry*. William S. Massey. IV(33)

M, W, F, 10.30-11.20.

Applications of calculus to the study of the geometry of curves and surfaces in Euclidean space, intrinsic differential-geometric properties of manifolds, and connections with non-Euclidean geometries and topology. *After Mathematics* 27 or 47a. (RP)

*Mathematics* 70a (51160), *Set Theory*. Angus J. Macintyre. IV(23)

T, Th, 10-11.15.

Algebra of sets, finite, countable and uncountable sets. Cardinal numbers and cardinal arithmetic. Order types and ordinal numbers. The axiom of choice and the well-ordering theorem. *After Mathematics* 20a or the equivalent. (RP)

*Mathematics* 71b (51200), *Introduction to Mathematical Logic*. Joseph A. Sgro. IV(23)

T, Th, 10-11.15.

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The propositional calculus, deduction, and semantic interpretation. The lower predicate calculus, completeness, axiomatic set theory, problems in the foundations of mathematics. (RP)

MATHEMATICS AND COMPUTER SCIENCE

(See under *Computer Science and Mathematics*.)

MATHEMATICS AND ECONOMICS

(See under *Economics and Mathematics*.)

MATHEMATICS AND  
ENGINEERING AND APPLIED SCIENCE

A MINIMUM of fourteen term courses in mathematics and engineering and applied science above the Sophomore level is required, with at least six in each of the two subjects. Consult James Lepowsky or Charles A. Walker.

MATHEMATICS AND PHILOSOPHY

THIS major is concerned with mathematics and mathematical logic, and with philosophical problems arising in the study of logic, mathematics, and science in general.

The program of study is as follows:

Freshman and Sophomore years: One of the regular two-term Freshman and Sophomore courses in mathematics each year, and two one-term courses in philosophy.

Junior and Senior years: Twelve term courses in mathematics and philosophy, with at least five in each subject. The mathematics courses should normally include a one-term course in analysis, a one-term course in abstract algebra, and a one-term course in geometry. By the end of Junior year Philosophy 30-1a and either Philosophy 30-1b or Mathematics 71b must have been completed. By the end of Senior year a one-term course in the philosophy of science must have been completed together with an advanced course in logic.

In their Senior year, students enrolled in this program will be asked to prepare an oral presentation of some topic, to be selected in consultation with members of the faculty. They will also be examined at this time on their general knowledge of logic and the foundations of mathematics.



Students of exceptional ability may write a Senior essay in lieu of two one-term courses in the Senior year with special permission. Consult Angus J. Macintyre or Frederic B. Fitch.

### MATHEMATICS AND PHYSICS

A MINIMUM of fourteen term courses in mathematics and physics above the Sophomore level is required, with at least six in each of the two subjects. Consult James Lepowsky and Peter D. M. Parker.

### MATHEMATICS, STATISTICS, AND ADMINISTRATIVE SCIENCES

(See under *Administrative Sciences, Mathematics, and Statistics.*)

### MEDICINE, PREPARATION FOR

(See under *Medicine in Chapter II.*)

### METEOROLOGY AND OCEANOGRAPHY

(See under *Geology and Geophysics.*)

### MOLECULAR BIOPHYSICS AND BIOCHEMISTRY

THE programs are designed to meet the needs of individuals who are interested in the molecular basis of biological processes, an interdisciplinary field of inquiry. These courses of study are well suited to students who plan to go to medical school or pursue graduate studies in biochemistry, biophysics, or a related discipline.

Two programs are offered. One leads to a B.S. degree, the other to a B.A. degree. The *B.S. major* is designed for students with a strong commitment to research in biochemistry and biophysics. It therefore provides an intensive introduction to research in this field. Students in this program usually pursue research projects in faculty laboratories during their Junior and Senior years. The *B.A. major* is designed for students who want the intellectual discipline of biochemistry and biophysics but wish to have sufficient time to pursue in depth studies outside the major. The B.A. major also meets the needs of those who are interested in molecular biology as a liberal education.

#### REQUIREMENTS FOR THE B.S. DEGREE

The departmental requirements for the B.S. degree (a total of 24 term courses) are listed below. Courses with daggers (†) may be waived on the basis of advanced placement.

Biology †11 and one of the following: Biology 31a, 32b, 33a, 35b, 38b, 39b, 43a, 55b.

Chemistry †10 (or 15 or 25); Chemistry 29 (or 27 or 33) and the associated laboratory course; Chemistry 34 (or two terms of advanced physical chemistry).

Mathematics †12a, †15b, 20a.

Physics 13 (or 25 or the three-term sequence 14a, 15b, 23a).

M.B.&B. 60a, 63b, 40a and b.

Four terms of electives, to be chosen in consultation with a departmental adviser, from courses offered by the following departments: Molecular Biophysics and Biochemistry, Biology, Chemistry, Physics, Mathematics, Computer Science, Anatomy, Microbiology, Physiology, Psychology, and Engineering and Applied Science.

#### REQUIREMENTS FOR THE B.A. DEGREE

The departmental requirements for the B.A. major (a total of 20 term courses) are listed below.

The required courses in biology, chemistry, mathematics, and physics are the same as for the B.S. degree.

M.B. & B. 30a or 41a, and 30La.

Three terms of electives, to be chosen in consultation with a departmental adviser.

#### RECOMMENDED COURSES

A term of mathematics beyond 20a is recommended (e.g., M.B. & B. 25b, Mathematics 22a, 41a, 46a).

Chemistry 10 (or 15 or 25 or 27), Mathematics 12a, 15b, and Biology 11 (or a physics course) should be taken during the Freshman year.

Members of the Molecular Biophysics and Biochemistry Committee on the Undergraduate Major are available for consultation throughout the year. Committee members, who are the only departmental advisers eligible to approve students' course schedules at the beginning of each term, are:

Class of 1975: B.S. majors, Frederic M. Richards, 202 KBT (6-2032); B.A. majors, Ted W. Reid, 202 BML (6-4868).

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Yale College Programs of Study

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whose members know one another well and learn from one another. Each college has its own library, dining hall, kitchen, common rooms, and athletic teams; each college offers courses for which academic credit is given; and each college celebrates the progress of the academic year with various festivities, including concerts and dramatic presentations.

There are twelve colleges: Berkeley, Branford, Calhoun, Davenport, Timothy Dwight, Jonathan Edwards, Morse, Pierson, Saybrook, Silliman, Ezra Stiles, and Trumbull. At the head of each college is a resident master. In each college a dean advises students on both academic and non-academic matters. Associated with the master and the dean as fellows are about fifty members of the faculty, drawn from different departments and schools of the University. A few fellows reside in the college, others have offices there. Freshmen are assigned to a college normally as nonresident members; those who live on the Old Campus may take a limited number of meals in the college and participate fully in its life. After Freshman year students live in the college to which they have been assigned and normally continue members of the same college throughout their undergraduate careers.

## FRESHMAN AND SOPHOMORE YEARS

MUCH of the lasting benefit of undergraduate study at Yale will depend on careful planning by the student of his program of study. It is important for him to seek aid and counsel from advisers. Freshmen in particular should seek help from resident Freshman counselors, the faculty program advisers assigned to them from the fellowships of their residential colleges, their college deans, and placement officers and directors of undergraduate studies in the various departments and programs in Yale College. Even with such assistance, however, it is probably impossible, and in fact it would be imprudent, for a student to map out at the beginning of Freshman year a firm schedule of studies for the next eight terms. Yet it is important to think ahead, and to keep certain principles and requirements in mind during the first two years of college.

One of the distinguishing features of a liberal education is that it has no single definition. Yale consequently does not prescribe any specific course to be taken by a student, but instead urges each undergraduate to design for himself his own program of study, suited to his particular needs and interests, from the multitude of courses available to college students in a university.

T: 8 terms over 4 years → 2 per year, indicating semesters

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But it is also true of a liberal education that it is not narrowly focused nor too diffuse. educational policy, stood by the studies as strongly as it has at Yale thus requires each student to choose an area of concentration in one departmental or special. Yale study should be characterized, particularly by the wide diversity of subject matter. Yale College has therefore formalized its policy embodied in the Distributional Requirements, which include the selection of courses outside the college.

1. A Freshman may earn at least two course credits in a single Distributional Group I or II.

2. To qualify for the Distributional Group V, a student must earn at least twelve course credits, of which at least six must be in Group V, to meet this requirement.

For the purpose of distributional requirements, the curriculum is divided into four Groups according to the following criteria:

*Group I* includes courses in foreign, ancient or modern languages.

*Group II* includes courses in history, history of art, history of science, philosophy, and religious studies.

*Group III* includes courses in natural science, astronomy, geology, archeology, economics, psychology, sociology, and anthropology.

*Group IV* includes courses in computer science, engineering, mathematics, molecular biology, and statistics.

\*The Group number of a course is indicated by a number in the left margin of the course entry in the Catalog. Other than those named here, the Group number is determined upon recommendation from the





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are also offered to prepare students to meet the language requirements of the Graduate School.

In 1975 the Institute offered courses in the following languages: Arabic, Bulgarian, Chinese (Mandarin), Czech, Dutch, French, German, Greek, Hebrew, Hungarian, Italian, Japanese, Latin, Lithuanian, Polish, Portuguese, Russian, Serbo-Croatian, Spanish, Swedish, and Ukrainian. For fuller information contact Charles A. Porter, Director, Summer Language Institute, Yale University, New Haven, Conn. 06520.

#### UNDERGRADUATE PROGRAM FOR TEACHER PREPARATION

This program assists thirty Juniors and thirty Seniors in meeting requirements for certification to teach in public schools at the secondary level. The student should apply to the Teacher Preparation Program in the second term of Sophomore year in order to complete the necessary courses and to plan a schedule that will allow him to undertake practice teaching during one term of Senior year. Full information is given below under Teacher Preparation in CHAPTER II.

#### UPPER-CLASS YEARS: MAJOR PROGRAMS

At the beginning of Sophomore year, students choose the degree for which they wish to qualify. Those seeking the B.S. degree elect their majors at this time. Those seeking the B.A. degree postpone the formal election of their major until the beginning of Junior year. The student's schedule for Sophomore year must be signed by a member of the faculty with whom the program has been discussed, unless the planned major is in science, mathematics, administrative sciences, or engineering and applied science. In such cases, the schedule needs the approval of the appropriate Director of Undergraduate Studies or his designated representative.

All candidates for a bachelor's degree in Yale College must elect one of the major programs on the list on page 50. These programs are described in general terms on the following pages, and in more detail in the announcement of the courses in CHAPTER II. In every case the student shall plan his schedule of courses in his major subject or field in consultation with a representative of the department or program concerned, and must secure the consultant's written approval. The student should acquaint himself fully with all the requirements of the major he plans to enter, with regard not merely to his immediate choice of courses but to the plan of his entire work in his last two or three years in college.

#### THE DEPARTMENTAL MAJOR (B.A. OR B.S.)

The departmental major normally consists of at least ten or twelve term courses, usually taken during Junior and Senior years, in a single subject. In some departments, a limited number of courses in related fields may be offered in fulfillment of the requirements of the major. Most majors have prerequisites of two term courses taken in Freshman or Sophomore years; in some majors, depending on the requirements of the discipline and the student's level of preparation, the number of prerequisite courses may be higher.

The departmental major may be either standard or intensive, though some departments make no distinction between the two. In an intensive major, the student takes prescribed seminar or tutorial courses and writes a Senior essay, undertakes a project, or completes a graduate course.

In every major, each student must pass a departmental examination or its equivalent. In most departments, a Senior essay or Senior project takes the place of the departmental examination.

Descriptions of the various departmental majors appear in alphabetical order in CHAPTER II.

#### SPECIAL DEPARTMENTAL MAJOR

In special cases, a department may recommend to the Executive Committee of Yale College that a student be awarded credit for from four to six term courses for a Senior project of such a nature that it does not fit into the ordinary departmental program. Such a student must also complete at least three term courses during Senior year. Consult the appropriate Director of Undergraduate Studies.

#### SPECIAL MAJORS

Special majors include such interdepartmental or interdisciplinary majors as those in Administrative Sciences, Mathematics, and Statistics; Afro-American Studies; American Studies; Archeology; Astronomy and Physics; British Studies; Chinese Studies; Combined Major in Literature; Combined Sciences; Computer Science and Mathematics; Economics and Mathematics; History, the Arts, and Letters; Japanese Studies; Latin American Studies; Literature; Mathematics and Engineering and Applied Science; Mathematics and Philosophy; Philosophy; Mathematics and Physics; Physics and Philosophy; Political and Economic Systems; Russian and East European Studies. Full descriptions appear in CHAPTER II.

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## IV

### ACADEMIC REGULATIONS

#### A. REQUIREMENTS FOR THE BACHELOR'S DEGREE

**T**O qualify for the bachelor's degree, B.A. or B.S., a student must successfully complete thirty-six term courses or their equivalent in Yale College. In doing so, he must fulfill the Distributional Requirements of Yale College, and he must complete the requirements of a major program, whether departmental or special. A student may complete no more than eight terms of enrollment in order to fulfill these requirements.

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##### DISTRIBUTIONAL REQUIREMENTS

The Distributional Requirements are described in detail in CHAPTER I of this bulletin. The subjects of instruction in Yale College are divided into four Distributional Groups. A student must earn a total of at least twelve course credits drawn from outside the Distributional Group which includes his major; no more than six course credits in a single Group may be employed to meet this requirement. College Credits or acceleration credits may be applied to the Distributional Requirements; see "Advanced Placement and Acceleration Credits" in CHAPTER I.

1. A student in a special major program which includes more than one Group should, in consultation with his Director of Undergraduate Studies, determine the Group in which his studies chiefly lie, and fulfill the Distributional Requirements accordingly, with that Group being considered the Group of his major.

2. A student who has been given permission to complete the requirements of two major programs, each of them in a different Group, may, for the purposes of the Distributional Requirements, consider himself as having only one major. See Two MAJORS in Section K.

##### MAJOR REQUIREMENTS

The requirements of the various major programs are given in CHAPTER II. Every major program includes a departmental examination or the equivalent. In most majors, a Senior essay or a Senior project takes the place of the examination. The Senior examination



is scheduled on two weekdays preceding the examination period in the spring term. In a department or program in which there is a two-day written Senior examination on those days, a Senior may, with the written consent of his instructors, be excused from not more than two second-term examinations in the major. In a department or program in which the Senior examination takes place on only one of the two scheduled days, a Senior may, with the written consent of the instructor, omit one second-term examination in the major. If the Senior examination takes place before the scheduled days, or if a Senior essay or Senior project takes the place of the examination, a student may not omit a course examination.

#### EIGHT TERMS OF ENROLLMENT

Normally students may not complete more than eight terms of enrollment for credit toward a bachelor's degree. A student may, however, in exceptional circumstances petition the Yale College Executive Committee for permission to enroll for an additional term. Such a petition should be made at the beginning of the student's seventh term; it should describe clearly the academic and educational reasons necessitating additional time for the student to take the degree, and it should be accompanied by the written support of the student's Director of Undergraduate Studies and faculty adviser. Degree enrollment (but not supplemental or part-time enrollment) in the Yale summer term constitutes one of a student's eight terms of enrollment for the bachelor's degree.

### B. GRADES

#### LETTER GRADES

THE passing letter grades in Yale College are as follows:

A	Excellent
B	Very Good
C	Good
D	Passing

#### CREDIT/FAIL OPTION

In order to encourage academic experimentation and to promote the diversity in students' programs intended by the Distributional Guidelines and the Distributional Requirements, the Yale College Faculty has provided that students may elect a certain number of courses on a Credit/Fail basis. Beginning with the fall term of 1975-76, for each term that a student is enrolled in Yale College, he may

offer one course credit earned on a Credit/Fail basis toward the requirements of the bachelor's degree. A student who begins the beginning of the fall term of 1975-76 and who will graduate after two additional terms of enrollment may elect a maximum of eight such credits for graduation.

1. Whether or not a particular course is available on a Credit/Fail basis is determined by the notation CR in the course listing.

2. A student may elect no more than one course on a Credit/Fail basis, and in no more than two courses, representing at least two credit hours.

3. Until midterm, a student who has elected a course on a Credit/Fail basis may choose to receive a letter grade. After midterm such conversion is not permitted.

4. A course once elected for a letter grade may not be converted to a course taken on a Credit/Fail basis.

5. In all courses, instructors report grades on that basis, the Registrar converts the notation CR, which is entered on the student's transcript.

6. Unless otherwise specified, courses in the Schools of Arts and Sciences and in the professional schools are not available on a Credit/Fail basis.

#### GENERAL REGULATIONS

1. Passing grades (A, B, C, D, C-) are reported to the Registrar. A student's public transcript, in which passing grades have been earned, is available to the Registrar.

2. All passing grades carry full credit toward the bachelor's degree. A grade of C- with a higher grade in some other course may be substituted for a C grade.

3. Non-passing marks, such as I, W, and Withdrew Failing, are reported to the Registrar. See REQUIREMENTS FOR GOOD STANDING in Section F, WARNING IN SECTION F, and ACADEMIC REASONS in Section I.

4. A grade, once reported to the Registrar, may not be changed, except