# *MAJOR FIELD TESTS*

Colleges and universities use the Major Field Tests to measure student academic achievement and growth and to assess the educational outcomes of their major programs. In addition, academic departments use the Major Field Tests to evaluate their curricula and to measure the progress of their students. The tests also provide students with an assessment of their own level of achievement within a field of study compared to that of students in their program and to national comparative data.

## Background

Development of the Major Field Tests began in 1989, modeled on the development of the Graduate Record Examinations (GRE) Subject Tests. However, unlike the GRE Subject Tests, the Major Field Tests do not serve as a predictor of graduate school success, but are designed to measure the basic knowledge and understanding achieved by senior undergraduates in their major field of study. Each test is revised approximately every five years. Experienced teaching faculty members representing all the relevant areas of a discipline participate in determining test specifications, questions, and types of scores reported. ETS assessment experts subject each question to rigorous tests of sensitivity and reliability. In addition, every effort is made to include questions that assess the most common and most important topics and skills within each major field of study.

## Test Content

The Major Field Tests are designed to assess mastery of concepts, principles, and knowledge expected of students at the conclusion of an academic major in specific subject areas. In addition to factual knowledge, the tests evaluate students' abilities to analyze and solve problems, understand relationships, and interpret material. The tests may contain questions that require interpretation of graphs, diagrams, and charts based on material related to the field. Academic departments may add up to 50 additional locally written questions to test areas of a discipline that may be unique to the department or institution.

## Test Length

The tests are two-hour multiple-choice tests. The addition of optional, locally developed questions may require a longer testing period.

## Test Administration

Departments or schools choose when and where to give the tests; however, the tests are normally administered during the senior year when students have completed the majority of courses in the major. Many institutions administer the tests as part of the requirements of a capstone course.

## National Comparative Data

A Comparative Data Guide, published each year, contains tables of scale scores and percentiles for individual student scores, departmental mean scores, and any subscores or group assessment indicators that the tests may support. The tables of data are drawn from senior-level test takers at a large number of diverse institutions. More than 500 colleges and universities employ one or more of the Major Field Tests for student achievement and curriculum evaluation each year.

## Scores

Major Field Test score reports are sent directly to the office within an institution that purchases them, such as a department chairperson, dean, or director of testing. Results of the tests are reported for the entire group of test takers, as well as for individual students. Overall student scores are reported on a scale of 120-200; subscores (which many of the tests include) are reported on a scale of 20-100. Another score reported for most of the tests is based on group-level achievement in subfields of the discipline. These "assessment indicators" report the average percent of a subset of test questions answered correctly by all students tested. On Major Field Tests, only correct answers are scored, so students are not penalized for omissions or guesses.

# *MATHEMATICS*

# *MATHEMATICS II (3VMF)*

(Current form introduced in January 1999)

The Major Field Test in Mathematics consists of 50 questions, some of which may be grouped in sets and based on such materials as diagrams and graphs. The questions are drawn from the courses of study most commonly offered as part of an undergraduate mathematics curriculum.

The outline below shows the content areas covered on the test and the approximate distribution of questions among the areas.

I. Calculus (30 percent) (The usual material of 3 semesters of calculus including single variable calculus and multivariable calculus.)

II. Algebra (30 percent)

A. Linear algebra
1. Matrices
2. Linear transformations
3. Characteristic polynomials
4. Eigenvalues and eigenvectors
5. Vector spaces
6. Systems of linear equations

B. Abstract algebra
1. Elementary theory of groups, rings, and fields
2. Elementary topics from number theory

III. Additional Topics (40 percent)

A. Advanced calculus (The standard subjects of an advanced calculus/beginning analysis course, including limits, Cauchy series, and general convergence of sequences, series and functions. All problems in either single or multivariable calculus are classified as regular calculus problems.)
B. Real analysis
C. Real-line topology
D. Discrete mathematics (graph theory and combinatorics)
E. Probability and statistics
F. Dynamical systems
G. Topology
H. Geometry (Euclidean, non-Euclidean, and differential geometry)
I. Differential equations (The standard subjects in a first semester course on differential equations that are not covered in the calculus sequence. Problems such as exponential decay are classified as calculus problems.)
J. Numerical analysis
K. Complex analysis

The relative percentages of mathematics questions at various cognitive levels is as follows:

a. Routine (55 percent)

Involves only two or three definitions and no more than a two-step reasoning process; or involves a possibly more complicated standard technique normally taught and practiced extensively in a course that is generally required or strongly recommended for all math majors at most institutions.

b. Nonroutine (25 percent)

Includes all items that are considered insightful. Also includes those requiring several steps of reasoning and those that require either the use of several definitions or a "new" definition given in the item that the student would not be expected to know. Also includes those items that require bringing techniques from two or more areas to bear on one problem, *e.g.*, treating functions from calculus as elements of an algebraic system.

c. Applied (20 percent)

There is conceptual overlap between "Applied" and "Routine-Nonroutine." Into which of these a given question is placed depends primarily on the general nature of the question. All "real world" settings go into the "Applied" category. Some others may also, but generally, standard applications of mathematics to other mathematics does not, e.g., the slope of a tangent line is an application of calculus to geometry but would not be considered "Applied" as used here.

Scores on the Mathematics II test are reported as follows:

**Total Score**
Reported for each student and summarized for the group.

**Assessment Indicators**
Reported for the group* only.

- Calculus (15)
- Algebra (15)
- Routine (27-28)
- Nonroutine (12-13)
- Applied (10)

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Numbers in parentheses are the approximate number of questions in each category.

*A minimum of five student reports is required for assessment indicators to be reported.

# *MATHEMATICS II TEST*
# *SAMPLE QUESTIONS*

The following questions illustrate the range of the test in terms of the abilities measured, the disciplines covered, and the difficulty of the questions posed. They should not, however, be considered representative of the entire scope of the test in either content or difficulty. An answer key follows the questions.

1. On a questionnaire, a respondent must choose 3 of the 5 questions presented. How many different combinations of 3 questions can the respondent possibly choose?

   (A) 10
   (B) 15
   (C) 20
   (D) 30
   (E) 60

2. A function $\boldsymbol{f}$ has the property that, at every point $(x,y)$ on the curve $y = \boldsymbol{f}(x)$, the slope of the line tangent to the curve is equal to $2xy$. Which of the following best describes the function $\boldsymbol{f}$ ?

   (A) Inverse trigonometric
   (B) Conic
   (C) Exponential
   (D) Linear
   (E) Logarithmic

3. Let $A$ and $B$ be metric spaces and let $f : A \to B$. Suppose that whenever $X$ is an open set in $B$, the set $\{a \in A : f(a) \notin X\}$ is closed in A. Which of the following must be true?

   I. $f$ is injective.
   II. $f$ is continuous.
   III. $f$ is a homeomorphism.

   (A) None
   (B) II only
   (C) III only
   (D) I and III only
   (E) I, II, and III

4. In the $xy$-plane, the line that is tangent to the graph of $y = x^2$ at the point (2,4) has a slope of

   (A) ½
   (B) 1
   (C) 2
   (D) 4
   (E) 8

5. The set {1, 2, 4, 7, 8, 11 ,13, 14} forms a group under the operation of multiplication modulo 15. Which of the following is the cyclic subgroup generated by {7}?

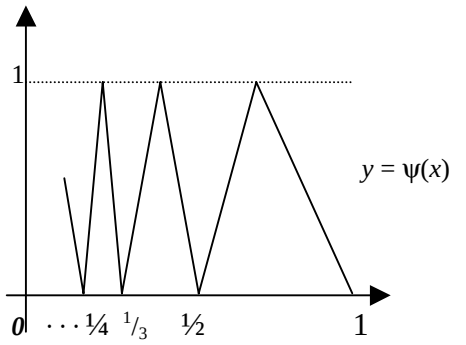
   (A) {1, 7}
   (B) {1, 4, 7, 13}
   (C) {4, 7, 11, 14}
   (D) {1, 2, 7, 14}
   (E) {1, 7, 8, 13, 14}

6. For each real number $t \neq 0$, define the function $\phi_t: \mathbf{R} \to \mathbf{R}$ by $\phi_t(x) = |x|^{|t|}$. A subset A of real numbers is called invariant with respect to the collection of functions $\phi_t$ if $\phi_t(A) \subseteq A$ for each $t \neq 0$. For this collection of functions, which of the following intervals is (are) invariant?

   I. (0, 1]
   II. [0, ½)
   III. (0, ∞)

   (A) I only
   (B) II only
   (C) III only
   (D) I and III
   (E) II and III

7.




The graph of a continuous nonnegative function $y = \psi(x)$ is indicated above, where $\psi(0) = 0$ and $\psi\left(\frac{1}{n}\right) = 0$ for each positive integer $n$. If the graph of $y = \psi(x)$ between $x = \frac{1}{n+1}$ and $\frac{1}{n}$ consists of the congruent sides of an isosceles triangle of height 1 for each positive integer $n$, then $\int_0^1 \psi(x)dx =$

(A) ½
(B) ¼
(C) $^1/_\pi$
(D) $^1/_e$
(E) $^2/_e$

8. The function $f$ is differentiable on the interval $0 \le x \le 2$. If $f(0) = 1$ and $f(2) = 7$, what value must the derivative have at least once in the interval $0 < x < 2$?

(A) 1
(B) 2
(C) 3
(D) 4
(E) 6

9. The determinant of the matrix product $\begin{pmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \end{pmatrix}\begin{pmatrix} 0 & 1 \\ 0 & -1 \\ 1 & 0 \end{pmatrix}$ is

(A) undefined
(B) 1
(C) 0
(D) –1
(E) –2

10. If $V_n$ is the vector space of all $n$-tuples of real numbers for each $n > 1$, which of the following must be true?

I. Every basis of $V_n$ contains exactly $n$ vectors
II. Every basis of $V_n$ is an orthogonal set of vectors
III. Every set of $n + 1$ vectors of $V_n$ is a linearly dependent set.

(A) I only
(B) II only
(C) I and II
(D) I and III
(E) II and III

ANSWER KEY

| | |
|---|---|
| 1. | A |
| 2. | C |
| 3. | B |
| 4. | D |
| 5. | B |
| 6. | D |
| 7. | A |
| 8. | C |
| 9. | E |
| 10. | D |