

**THE ONLY REVIEW GUIDE WITH ACTUAL  
—NOT SIMULATED—TEST QUESTIONS**

**THE  
OFFICIAL  
GUIDE FOR  
GMAT  
REVIEW**

**1988—90 EDITION**

**THE ONLY SOURCE OF ACCURATE INFORMATION ABOUT THE GMAT**

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# **THE OFFICIAL GUIDE FOR GMAT REVIEW**

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**Prepared for the  
Graduate Management Admission Council  
by Educational Testing Service**

Inquiries concerning this publication should be directed to GMAT Program Direction Office,  
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USA: 0-446-35302-7  
CAN: 0-446-35303-5

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# Graduate Management Admission Council

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The Graduate Management Admission Council (GMAC) is an organization of graduate business and management schools sharing a common interest in professional management education. The Council provides information to schools and prospective students to help both make reasoned choices in the admission process. It also provides a forum for the exchange of information through research, educational programs, and other services among the broad constituency of individuals and institutions concerned with management education.

The Council has three basic service objectives:

1. to enhance the management education admission process by:
  - developing and administering appropriate assessment instruments;
  - developing other services and materials related to the selection process;
  - informing schools and students about the appropriate use of such instruments and materials;
  - providing opportunities for the exchange of information between students and schools.

2. to broaden knowledge about management education by:

- conducting educational research;
- disseminating information about relevant research;
- encouraging the development and exchange of information by professionals in the field.

3. to promote the highest standards of professional practice in the administration of management education programs and related activities by:

- developing appropriate standards of practice;
- offering educational programs and publications to provide essential knowledge, skills, and values;
- providing other opportunities for professional development.

The Council currently contracts with Educational Testing Service (ETS) for development of GMAT test material, administration of the GMAT test, and preparation and distribution of GMAT score reports. The Council also determines policies and procedures for research and development of the GMAT; for publication of materials for students,

guidance counselors, and admissions officers; and for nontesting services offered to management schools and applicants.

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# Introduction

*The Official Guide for GMAT Review* has been designed and written by the staff of Educational Testing Service, which prepares the Graduate Management Admission Test used by many graduate schools of business and management as one criterion in considering applications for admission to their graduate programs. This book is intended to be a general guide to the kinds of verbal and mathematical questions likely to appear in the GMAT. All questions used to illustrate the various types of questions are taken from actual editions of the GMAT administered between June 1982 and June 1987.\*

The GMAT is not a test of knowledge in specific subjects—for example, it does not test knowledge specifically or uniquely acquired in accounting or economics courses. Rather, it is a test of certain skills and abilities that have been found to contribute to success in graduate programs in business and management. For this reason, it is useful to familiarize yourself with the general types of questions likely to be found in editions of the GMAT and the reasoning skills and problem-solving strategies that these types of questions demand. This book illustrates various types of questions that appear in the GMAT and explains in detail some of the most effective strategies for mastering these questions.

The most efficient and productive way to use this book is to read first through Chapter 1. Each type of question is briefly described, the directions are given, one or two examples are presented, and the skills each question type measures are outlined. You should pay particular

attention to the directions for each question type. This is especially important for the Data Sufficiency questions, which have lengthy and complex directions.

Chapters 3-7 provide detailed illustrations and explanations of individual question types. After you read Chapter 1, you will find the most advantageous way to use the book is to choose a chapter on a particular question type, read carefully the introductory material, and then do the sample test sections in that chapter. As you take the sample test sections, follow the directions and time specifications given. When you complete a sample test section, use the answer key that follows it to check your responses. Then review the sample test section carefully, spending as much time as is necessary to familiarize yourself with the range of questions or problems presented in the sample test section.

You may find it useful to read through all of Chapter 2, Math Review, before working through Chapters 3, Problem Solving, and 4, Data Sufficiency, or you may wish to use Chapter 2 as a reference, noting—in Chapters 3 and 4—the suggested sections at the end of each explanation following the first sample test sections as you go along. However, since Chapter 2 is intended to provide you with a comprehensive review of the basic mathematical concepts used in the quantitative sections of the GMAT, you may find it valuable to read through the chapter as a whole.

The introductory material, sample test sections, and answer keys to the sample test sections in Chapter 5, Reading Comprehension, Chapter 6, Critical Reasoning, and Chapter 7, Sentence Correction, should be approached in the way suggested above. The explanatory materials for Reading Comprehension and Critical Reasoning have been written as thorough explanations of the reasoning and problem-solving challenges each

question type presents. Demonstrating strategies for successfully meeting these challenges, regardless of the particular content of the questions or problems that appear in a specific edition of the GMAT, is the objective of these explanations.

After you complete the review and practice built in to each chapter you should turn to Chapter 8, which includes an authentic GMAT test. It will be most helpful in preparing yourself to take the GMAT if you regard the test in Chapter 8 as a facsimile of the test you will take for scoring. Time yourself on each section, and follow the directions exactly as given.

Following the test reprinted in Chapter 8 is an answer key, information about scoring and score interpretation, and an explanation for every question on that test. Guidelines for the use of GMAT scores are also given.

\*The material in *The Official Guide for GMAT Review* is intended to familiarize you with the types of questions found on the GMAT. Although the questions on the sample test sections in Chapters 3-7 represent the general nature of the questions on the test, it is possible that a type of question not illustrated by and explained in the *Guide* may appear on the GMAT. It is also possible that material illustrated by and explained in the *Guide* may not appear on the test.

# 1 Description of the Graduate Management Admission Test

The Graduate Management Admission Test is designed to help graduate schools assess the qualifications of applicants for advanced study in business and management. The test can be used by both schools and students in evaluating verbal and mathematical skills as well as general knowledge and preparation for graduate study. Note, however, that GMAT scores should be considered as only one of several indicators of ability.

## Format

The current GMAT consists entirely of multiple-choice questions, which are divided among seven separately timed sections; the total testing time is about three and a half hours. Each question offers five choices from which the examinee is to select the best answer.

Every form of the test contains one section of trial questions that are needed for pretesting and equating purposes. These questions, however, are not identified, and you should do your best on all questions. The answers to trial questions are not counted in your test score.

Both the Graduate Management Admission Council and Educational Testing Service are aware of the limits of the multiple-choice format, particularly in measuring an applicant's ability to formulate general concepts or to develop detailed supportive or opposing arguments. However, in a national testing program designed for a wide variety of people with different backgrounds, the use of a large number of short, multiple-choice questions has proved to be an effective and reliable way of providing a fair and valid evaluation of specific skills.

## Content

It is important to recognize that the GMAT evaluates skills and abilities that develop over relatively long periods of time. Although the sections are basically verbal or mathematical, the complete test provides one method of measuring overall ability. The GMAT does not test specific knowledge obtained in college course work, and it does not seek to measure achievements in any specific areas of study.

The Graduate Management Admission Council recognizes that questions arise concerning techniques for taking standardized examinations such as the GMAT, and it is hoped that the descriptions, sample test sections, and explanations given here, along with the authentic test, will give you a practical familiarity with both the concepts and techniques required by GMAT questions.

The material on the following pages provides a general description and brief discussion of the objectives and techniques for each question type.

Following this general description of the GMAT are a math review designed to help you review basic mathematical skills useful in the Problem Solving and Data Sufficiency sections of the GMAT and five chapters, one for each question type, that present sample test sections with answer keys and detailed explanations of the specific question types and of all questions and answers from the sample test sections. (The sample test sections are made up of questions that have appeared in the actual GMAT.) Methods of determining the best answer to a particular kind of question as well as explanations of the different kinds of questions appearing in any one section are also presented in these chapters. Chapter 8 contains an authentic GMAT test. This is followed by an answer key, explanations for each question, and scoring information,

which explains how GMAT scores are calculated and how they are interpreted.

## Problem Solving Questions

This section of the GMAT is designed to test (1) basic mathematical skills, (2) understanding of elementary mathematical concepts, and (3) the ability to reason quantitatively and to solve quantitative problems. Approximately half the problems in the test are in a mathematical setting; the remainder are based on "real life" situations.

### WHAT IS MEASURED

Problem Solving questions test your ability to understand verbal descriptions of situations and to solve problems using arithmetic, elementary algebra, or commonly known concepts of geometry.

The directions for Problem Solving questions read as follows:

*Directions:* In this section solve each problem, using any available space on the page for scratchwork. Then indicate the best of the answer choices given.

*Numbers:* All numbers used are real numbers.

*Figures:* Figures that accompany problems in this test are intended to provide information useful in solving the problems. They are drawn as accurately as possible EXCEPT when it is stated in a specific problem that its figure is not drawn to scale. All figures lie in a plane unless otherwise indicated.

## Data Sufficiency Questions

Each of the problems in the Data Sufficiency section of the GMAT consists of a question, often accompanied by some initial information, and two statements, labeled (1) and (2), containing additional information. You must decide whether sufficient information to answer the question is given by either (1) or (2) individually or—if not—by both combined.

These are the directions that you will find for the Data Sufficiency section of the GMAT. Read them carefully.

**Directions:** Each of the data sufficiency problems below consists of a question and two statements, labeled (1) and (2), in which certain data are given. You have to decide whether the data given in the statements are sufficient for answering the question. Using the data given in the statements plus your knowledge of mathematics and everyday facts (such as the number of days in July or the meaning of *counterclockwise*), you are to blacken space

- A if statement (1) ALONE is sufficient, but statement (2) alone is not sufficient to answer the question asked;
- B if statement (2) ALONE is sufficient, but statement (1) alone is not sufficient to answer the question asked;
- C if BOTH statements (1) and (2) TOGETHER are sufficient to answer the question asked, but NEITHER statement ALONE is sufficient;
- D if EACH statement ALONE is sufficient to answer the question asked;

E if statements (1) and (2) TOGETHER are NOT sufficient to answer the question asked, and additional data specific to the problem are needed.

**Numbers:** All numbers used are real numbers.

**Figures:** A figure in a data sufficiency problem will conform to the information given in the question, but will not necessarily conform to the additional information given in statements (1) and (2).

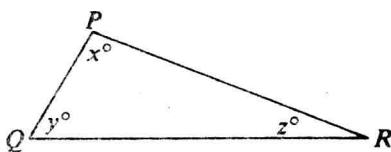
You may assume that lines shown as straight are straight and that angle measures are greater than zero.

You may assume that the position of points, angles, regions, etc., exist in the order shown.

All figures lie in a plane unless otherwise indicated.

**Example:**

In  $\triangle PQR$ , what is the value of  $x$ ?



- (1)  $PQ = PR$
- (2)  $y = 40$

**Explanation:** According to statement (1),  $PQ = PR$ ; therefore,  $\triangle PQR$  is isosceles and  $y = z$ . Since  $x + y + z = 180$ ,  $x + 2y = 180$ . Since statement (1) does not give a value for  $y$ , you cannot answer the question using statement (1) by itself. According to statement (2),  $y = 40$ ; therefore,  $x + z = 140$ . Since statement (2) does not give a value for  $z$ , you cannot answer the question using statement (2) by itself. Using both statements together you can find  $y$  and  $z$ ; therefore, you can find  $x$ , and the answer to the problem is C.

## WHAT IS MEASURED

Data Sufficiency questions are designed to measure your ability to analyze a quantitative problem, to recognize which information is relevant, and to determine at what point there is sufficient information to solve the problem.

## Reading Comprehension Questions

The Reading Comprehension section is made up of several reading passages about which you will be asked interpretive, applicative, and inferential questions. The passages are approximately 500 words long, and they discuss topics from the social sciences, the physical and biological sciences, and the humanities. Because each section includes at least one passage from each of the three areas, you will probably be generally familiar with some of the material; however, neither the passages nor the questions assume detailed knowledge of the topics discussed.

## WHAT IS MEASURED

Reading Comprehension questions measure your ability to understand, analyze, and apply information and concepts presented in written form. All questions are to be answered on the basis of what is stated or implied in the reading material, and no specific knowledge of the material is required. Reading Comprehension therefore, evaluates your ability to

- understand words and statements in the reading passages (Questions of this type are not vocabulary questions. These questions test your understanding of and ability to use specialized terms as well as your understanding of the English language. You may also find that questions of this type ask about the overall meaning of a passage);
- understand the logical relationships between significant points and concepts in the reading passages (For example, such questions may ask you to determine the strong and weak points of an argument or to evaluate the importance of arguments and ideas in a passage);
- draw inferences from facts and statements in the reading passages (The inference questions will ask you to consider factual statements or information and, on the basis of that information, reach a general conclusion);
- understand and follow the development of quantitative concepts as they are presented in verbal material (This may involve the interpretation of numerical data or the use of simple arithmetic to reach conclusions about material in a passage).

The directions for Reading Comprehension questions read as follows:

*Directions:* Each passage in this group is followed by questions based on its content. After reading a passage, choose the best answer to each question and blacken the corresponding space on the answer sheet. Answer all questions following a passage on the basis of what is *stated* or *implied* in that passage.

## Critical Reasoning Questions

The Critical Reasoning section of the GMAT is designed to test the reasoning skills involved (1) in making arguments, (2) in evaluating arguments, and (3) in formulating or evaluating a plan of action. Most of the questions are based on a separate argument or set of statements; occasionally, two or three questions are based on the same argument or set of statements. The materials on which questions are based are drawn from a variety of sources. No familiarity with the subject matter of those materials is presupposed.

### WHAT IS MEASURED

Critical Reasoning questions are designed to provide one measure of your ability to reason effectively in the areas of

- argument construction (Questions in this category may ask you to recognize such things as the basic structure of an argument; properly drawn conclusions; underlying assumptions; well-supported explanatory hypotheses; parallels between structurally similar arguments);
- argument evaluation (Questions in this category may ask you to analyze a given argument and to recognize such things as factors that would strengthen, or weaken, the given argument; reasoning errors committed in making that argument; aspects of the method by which the argument proceeds);
- formulating and evaluating a plan of action (Questions in this category may ask you to recognize such things as the relative appropriateness, effectiveness, or efficiency of different plans of action; factors that would strengthen, or weaken, the prospects of success for a proposed plan of action; assumptions underlying a proposed plan of action).

The directions for Critical Reasoning questions read as follows:

*Directions:* For each question in this section, select the best of the answer choices given.

## Sentence Correction Questions

Sentence Correction questions ask you which of the five choices best expresses an idea or relationship. The questions will require you to be familiar with the stylistic conventions and grammatical rules of standard written English and to demonstrate your ability to improve incorrect or ineffective expressions.

### WHAT IS MEASURED

Sentence Correction questions test two broad aspects of language proficiency:

1. *Correct expression.* A correct sentence is grammatically and structurally sound. It conforms to all the rules of standard written English (for example: noun-verb agreement, noun-pronoun agreement, pronoun consistency, pro-



noun case, and verb tense sequence). Further, a correct sentence will not have dangling, misplaced, or improperly formed modifiers, will not have unidiomatic or inconsistent expressions, and will not have faults in parallel construction.

2. **Effective expression.** An effective sentence expresses an idea or relationship clearly and concisely as well as grammatically. This does not mean that the choice with the fewest and simplest words is necessarily the best answer. It means that there are no superfluous words or needlessly complicated expressions in the best choice.

In addition, an effective sentence uses proper diction. (Diction refers to the standard dictionary meaning of words and the appropriateness of words in context.) In evaluating the diction of a sentence, you must be able to recognize whether the words are well chosen, accurate, and suitable for the context.

The directions for Sentence Correction questions read as follows:

**Directions:** In each of the following sentences, some part of the sentence or the entire sentence is underlined. Beneath each sentence you will find five ways of phrasing the underlined part. The first of these repeats the original; the other four are different. If you think the original is better than any of the alternatives, choose answer A; otherwise choose one of the others. Select the best version and blacken the corresponding space on your answer sheet.

This is a test of correctness and effectiveness of expression. In choosing answers, follow the requirements of standard written English; that is, pay attention to grammar, choice of words, and sentence construction. Choose the answer that expresses most effectively what is presented in the original sentence; this answer should be clear and exact, without awkwardness, ambiguity, or redundancy.

**Examples:**

A thunderclap is a complex acoustic signal as a result of rapid expansion of heated air in the path of a lightning flash

- (A) as a result of
- (B) caused as a result of
- (C) resulting because of the
- (D) resulting from the
- (E) that results because there is

In choice A, *is a . . . signal as a result of* is incorrect. It is the thunderclap that results from the expansion; its being a signal is irrelevant.

In choice B, it is superfluous to use both *caused* and *result*, and it is also superfluous to use both *result* and *because* in choices C and E. In choice C, *because of* is not the correct preposition to use after *resulting*; *from* is correct and is used in the best answer, D.

Ever since the Civil War, the status of women was a live social issue in this country.

- (A) Ever since the Civil War, the status of women was
- (B) Since the Civil War, women's status was
- (C) Ever since the Civil War, the status of women has been
- (D) Even at the time of the Civil War, the status of women has been
- (E) From the times of the Civil War, the status of women has been

In choice A, the verb following *women* should be *has been*, not *was*, because *ever since* denotes a period of time continuing from the past into the present. For the same reason, *was* is inappropriately used with *since* in choice B. In choice D, *even at* changes the meaning of the original sentence substantially and does not fit with *has been*; *was* is correct with *even at*. In choice E, *times* is incorrect; the standard phrase is *from the time of*. C is the best answer.

## General Test-Taking Suggestions

1. Although the GMAT stresses accuracy more than speed, it is important to use the allotted time wisely. You will be able to do so if you are familiar with the mechanics of the test and the kinds of materials, questions, and directions in the test. Therefore, become familiar with the formats and requirements of each section of the test.
2. After you become generally familiar with all question types, use the individual chapters on each question type in this book (Chapters 3-7), which include sample test sections and detailed explanations, to prepare yourself for the actual GMAT test in Chapter 8. When taking the test, try to follow all the requirements specified in the directions and keep within the time limits.



While this test is useful for familiarization, it cannot be used to predict your performance on the actual test.

3. Read all test directions carefully. Since many answer sheets give indications that the examinees do not follow directions, this suggestion is particularly important. The directions explain exactly what each section requires in order to answer each question type. If you read hastily, you may miss important instructions and seriously jeopardize your scores.
4. Answer as many questions as possible, but avoid random guessing. Your GMAT scores will be based on the number of questions you answer correctly minus a fraction of the number you answer incorrectly. Therefore, it is unlikely that mere guessing will improve your scores significantly, and it does take time. However, if you have some knowledge of a question and can eliminate at least one of the answer choices as wrong, your chance of getting the best answer is improved, and it will be to your advantage to answer the question. If you know nothing at all about a particular question, it is probably better to skip it. The number of omitted questions will not be subtracted.

5. Take a watch to the examination and be sure to note the time limit for each section. Since each question has the same weight, it is not wise to spend too much time on one question if that causes you to neglect other questions.
6. Make every effort to pace yourself. Work steadily and as rapidly as possible without being careless.
7. A wise practice is to answer the questions you are sure of first. Then, if time permits, go back and attempt the more difficult questions.
8. Read each question carefully and thoroughly. Before answering a question, determine exactly what is being asked. Never skim a question or the possible answers. Skimming may cause you to miss important information or nuances in the question.
9. Do not become upset if you cannot answer a question. A person can do very well without answering every question or finishing every section. No one is expected to get a perfect score.
10. When you take the test, you will mark your answers on a separate answer sheet. As you go through the test, be sure that the number of each answer on the answer sheet matches the corresponding question number in the test book. Your answer sheet may contain space for more answers or questions than there are in the test book. Do not be concerned, but be careful. Indicate each of your answers with a dark mark that completely fills the response position on the

answer sheet. Light or partial marks may not be properly read by the scoring machine. Indicate only one response to each question, and erase all unintended marks completely.

## GMAT: Test Specifications

All editions of the GMAT are constructed to measure the same skills and meet the same specifications. Thus, each section of the test is constructed according to the same specifications for every edition of the GMAT. These specifications include definite requirements for the number of questions, the points tested by each question, the kinds of questions, and the difficulty of each question.

Because the various editions of the test inevitably differ somewhat in difficulty, they are made equivalent to each other by statistical methods. This equating process makes it possible to assure that all reported scores of a given value denote approximately the same level of ability regardless of the edition being used or of the particular group taking the test at a given time.

## Test Development Process

Educational Testing Service professional staff responsible for developing the verbal measures of the GMAT have backgrounds and advanced degrees in the humanities or in measurement. Those responsible for the quantitative portion have advanced degrees in mathematics or related fields.

Standardized procedures have been developed to guide the test-generation process, to assure high-quality test material, to avoid idiosyncratic questions, and to encourage development of test material that is widely appropriate.

An important part of the development of test material is the review process. Each question, as well as any stimulus material on which questions are based, must be reviewed by several independent critics. In appropriate cases, questions are also reviewed by experts outside ETS who can bring fresh perspectives to bear on the questions in terms of actual content or in terms of sensitivity to minority and women's concerns.

After the questions have been reviewed and revised as appropriate, they are assembled into clusters suitable for trial during actual administrations of the GMAT. In this manner, new questions are tried out, under standard testing conditions, by representative samples of GMAT examinees. Questions being tried out do not affect examinees' scores but are themselves evaluated: they are analyzed statistically for usefulness and weaknesses. The questions that perform satisfactorily become part of a pool of questions from which future editions of the GMAT can be assembled; those that do not are rewritten to correct the flaws and tried out again—or discarded.

In preparing those sections of the GMAT that will contribute to the scoring process, the test assembler uses only questions that have been successfully tried out. The test assembler considers not only each question's characteristics but also the relationship of the question to the entire group of questions with respect to the test specifications discussed above. When the test has been assembled, it is reviewed by a second test specialist and by the test development coordinator for the GMAT.

After satisfactory resolution of any points raised in these reviews, the test goes to a test editor. The test editor's review is likely to result in further suggestions for change, and the test assembler must decide how these suggested changes will be handled. If a suggested change yields an editorial improvement, without jeopardizing content integrity, the change is adopted; otherwise, new wording is sought that will meet the dual concerns of content integrity and editorial style. The review process is continued at each stage of test assembly and copy preparation, down to careful scrutiny of the final proof immediately prior to printing.

All reviewers except the editor and proofreader must attempt to answer each question without the help of the answer key. Thus, each reviewer "takes the test," uninfluenced by knowledge of what the question writer or test assembler believed each answer should be. The answer key is certified as official only after at least three reviewers have agreed independently on the best answer for each question.

The extensive, careful procedure described here has been developed over the years to assure that every question in any new edition of the GMAT is appropriate and useful and that the combination of questions that make up the new edition is satisfactory. Nevertheless, the appraisal is not complete until after the new edition has been administered during a national test administration and subjected to a rigorous process of analysis to see whether each question yields the expected result. This further appraisal sometimes reveals that a question is not satisfactory after all it may prove to be ambiguous, or require information beyond the scope of the test, or be otherwise unsuitable. Answers to such questions are not used in computing scores.

# 2 Math Review

Although this chapter provides a review of some of the mathematical concepts of arithmetic, algebra, and geometry, it is not intended to be a textbook. You should use this chapter to familiarize yourself with the kinds of topics that are tested in the GMAT. You may wish to consult an arithmetic, algebra, or geometry book for a more detailed discussion of some of the topics.

The topics that are covered in Section A, arithmetic, include:

- |                                  |                                 |
|----------------------------------|---------------------------------|
| 1. Properties of integers        | 7. Percents                     |
| 2. Fractions                     | 8. Equivalent forms of a number |
| 3. Decimals                      | 9. Powers and roots of numbers  |
| 4. Real numbers                  | 10. Mean                        |
| 5. Positive and negative numbers | 11. Median                      |
| 6. Ratio and proportion          | 12. Mode                        |

The content of Section B, algebra, does not extend beyond what is covered in a first-year high school course. The topics included are:

- |   |   |
|---|---|
| 1. Simplifying algebraic expressions              | 5. Solving factorable quadratic equations |
| 2. Equations                                      | 6. Exponents                              |
| 3. Solving linear equations with one unknown      | 7. Absolute value                         |
| 4. Solving two linear equations with two unknowns | 8. Inequalities                           |

Section C, geometry, is limited primarily to measurement and intuitive geometry or spatial visualization. Extensive knowledge of theorems and the ability to construct proofs, skills that are usually developed in a formal geometry course, are not tested. The topics included in this section are:

- |                                  |                         |
|----------------------------------|-------------------------|
| 1. Lines                         | 8. Circles              |
| 2. Intersecting lines and angles | 9. Solids               |
| 3. Perpendicular lines           | 10. Rectangular solids  |
| 4. Parallel lines                | 11. Cylinders           |
| 5. Polygons (convex)             | 12. Pyramids            |
| 6. Triangles                     | 13. Coordinate geometry |
| 7. Quadrilaterals                |                         |

Section D, word problems, presents examples of and solutions to the following types of word problems:

- |             |                         |
|-------------|-------------------------|
| 1. Rate     | 6. Profit               |
| 2. Work     | 7. Sets                 |
| 3. Mixture  | 8. Geometry             |
| 4. Interest | 9. Measurement          |
| 5. Discount | 10. Data interpretation |

## A. Arithmetic

### 1. INTEGERS

An *integer* is any number in the set  $\{\dots, -3, -2, -1, 0, 1, 2, 3, \dots\}$ . If  $x$  and  $y$  are integers and  $x \neq 0$ ,  $x$  is a *divisor* (*factor*) of  $y$  provided that  $y = xn$  for some integer  $n$ . In this case  $y$  is also said to be *divisible* by  $x$  or to be a *multiple* of  $x$ . For example, 7 is a divisor or factor of 28 since  $28 = 7 \cdot 4$ , but 6 is not a divisor of 28 since there is no integer  $n$  such that  $28 = 6n$ .

Any integer that is divisible by 2 is an *even integer*; the set of even integers is  $\{\dots, -4, -2, 0, 2, 4, 6, 8, \dots\}$ . Integers that are not divisible by 2 are *odd integers*;  $\{\dots, -3, -1, 1, 3, 5, \dots\}$  is the set of odd integers.

If at least one factor of a product of integers is even, then the product is even; otherwise the product is odd. If two integers are both even or both odd, then their sum and their difference are even. Otherwise, their sum and their difference are odd.

A *prime number* is an integer that has exactly two different positive divisors, 1 and itself. For example, 2, 3, 5, 7, 11, and 13 are prime numbers, but 15 is not, since 15 has four different positive divisors, 1, 3, 5, and 15. The number 1 is not a prime number, since it has only one positive divisor.

The numbers  $-2, -1, 0, 1, 2, 3, 4, 5$  are *consecutive integers*. Consecutive integers can be represented by  $n, n + 1, n + 2, n + 3, \dots$ , where  $n$  is an integer. The numbers  $0, 2, 4, 6, 8$  are *consecutive even integers*, and  $1, 3, 5, 7, 9$  are *consecutive odd integers*. Consecutive even integers can be represented by  $2n, 2n + 2, 2n + 4, \dots$ , and consecutive odd integers can be represented by  $2n + 1, 2n + 3, 2n + 5, \dots$ , where  $n$  is an integer.

*Properties of the integer 1.* If  $n$  is any number, then  $1 \cdot n = n$ , and for any number  $n \neq 0$ ,  $n \cdot \frac{1}{n} = 1$ . The number 1 can be expressed in many ways, e.g.,  $\frac{n}{n} = 1$  for any number  $n \neq 0$ . Multiplying or dividing an expression by 1, in any form, does not change the value of that expression.

*Properties of the integer zero.* The integer zero is neither positive nor negative. If  $n$  is any number, then  $n + 0 = n$  and  $n \cdot 0 = 0$ . Division by zero is not defined.

## 2. FRACTIONS

In a fraction  $\frac{n}{d}$ ,  $n$  is the *numerator* and  $d$  is the *denominator*. The denominator of a fraction can never be zero, because division by zero is not defined.

Two fractions are said to be *equivalent* if they represent the same number. For example,  $\frac{4}{8}, \frac{3}{6}$ , and  $\frac{1}{2}$  are equivalent since all three represent the number  $\frac{1}{2}$ .

*Addition and subtraction of fractions.* To add or subtract two fractions with the same denominator, simply perform the required operation with the numerators, leaving the denominators the same. For example,  $\frac{3}{5} + \frac{4}{5} = \frac{3+4}{5} = \frac{7}{5}$ , and  $\frac{5}{7} - \frac{2}{7} = \frac{5-2}{7} = \frac{3}{7}$ . If two fractions do not have the same denominator, express them as equivalent fractions with the same denominator. For example, to add  $\frac{3}{5}$  and  $\frac{4}{7}$ , multiply the numerator and denominator of the first fraction by 7 and the numerator and denominator of the second fraction by 5, obtaining  $\frac{21}{35}$  and  $\frac{20}{35}$ , respectively;

$$\frac{21}{35} + \frac{20}{35} = \frac{41}{35}.$$

Also,

$$\frac{2}{3} + \frac{1}{6} = \frac{2}{3} \cdot \frac{2}{2} + \frac{1}{6} = \frac{4}{6} + \frac{1}{6} = \frac{5}{6}.$$

*Multiplication and division of fractions.* To multiply two fractions, simply multiply the two numerators and multiply the two denominators. For example,  $\frac{2}{3} \times \frac{4}{7} = \frac{2 \times 4}{3 \times 7} = \frac{8}{21}$ .

To divide by a fraction, invert the divisor (i.e., find its *reciprocal*) and multiply. For example,  $\frac{2}{3} \div \frac{4}{7} = \frac{2}{3} \times \frac{7}{4} = \frac{14}{12} = \frac{7}{6}$ .

In the problem above, the reciprocal of  $\frac{4}{7}$  is  $\frac{7}{4}$ . In general, the reciprocal of a fraction  $\frac{n}{d}$  is  $\frac{d}{n}$ , where  $n$  and  $d$  are not zero.