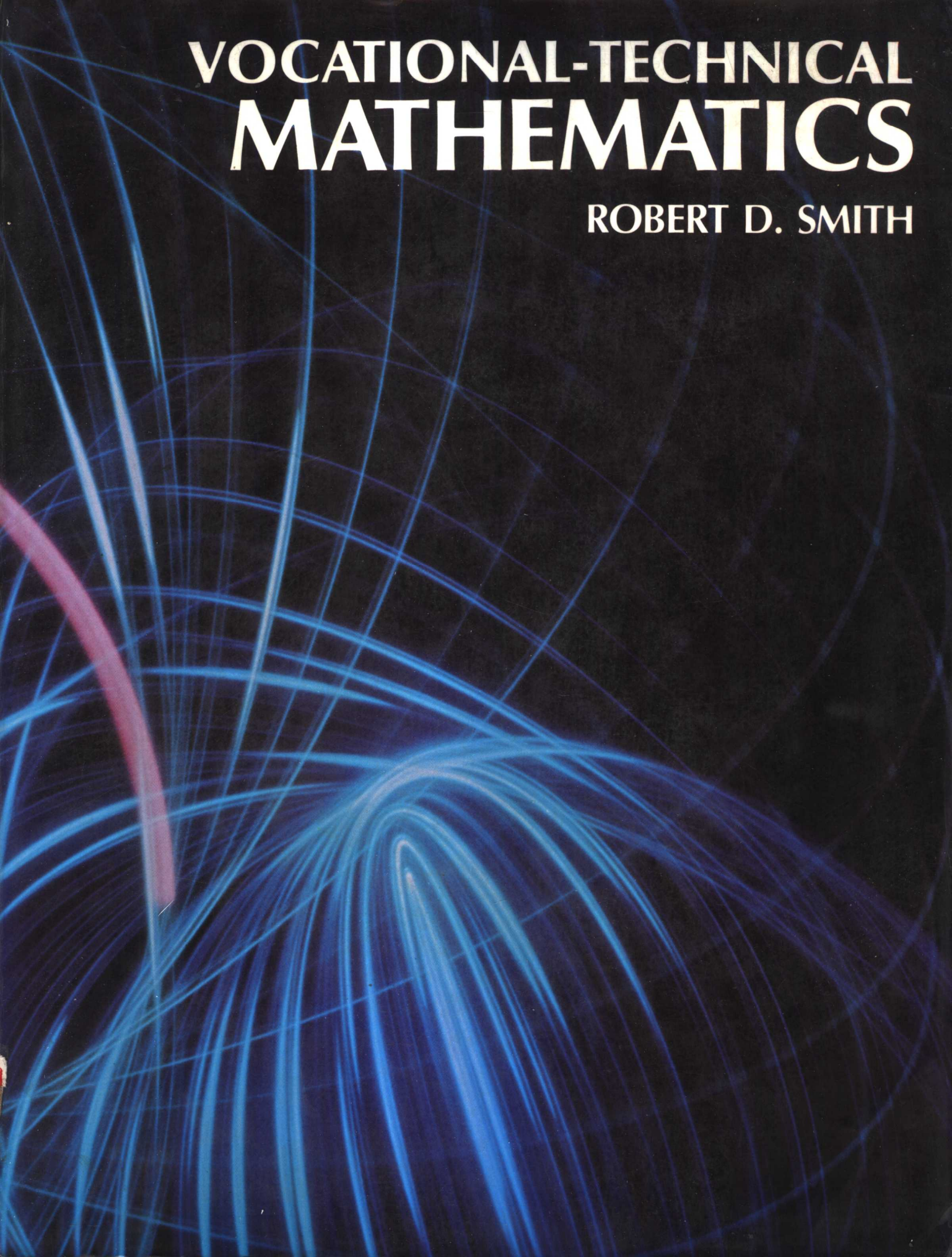


# VOCATIONAL-TECHNICAL MATHEMATICS

ROBERT D. SMITH



# **VOCATIONAL-TECHNICAL MATHEMATICS**

**ROBERT D. SMITH**

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2 Computer Drive-W, Box 15-015  
Albany, New York 12212

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**LIBRARY OF CONGRESS CATALOG CARD NUMBER: 81-70966  
ISBN: 0-8273-1882-0**

**PRINTED IN THE UNITED STATES OF AMERICA  
PUBLISHED SIMULTANEOUSLY IN CANADA  
BY NELSON CANADA,  
A DIVISION OF INTERNATIONAL THOMSON LIMITED**

*Vocational-Technical Mathematics* is dedicated to my wife, Kathy, and children, Dawn, Arline, and Eric. Their understanding, patience, and co-operation are gratefully acknowledged.

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# Vocational-Technical Mathematics

## PREFACE

*Vocational-Technical Mathematics* is written to provide practical vocational and technical applications of mathematical concepts. Presentation of concepts is followed by applied examples and problems which have been drawn from diverse occupational fields.

Both content and method are those used by the author in teaching related vocational-technical mathematics on both the secondary and post-secondary levels. Each unit is developed as a learning experience based on preceding units. The applied examples and problems progress from the simple to those whose solutions are relatively complex. Many problems require the student to work with illustrations such as are found in trade and technical manuals, handbooks, and drawings.

The book was written from material developed for classroom use and it is designed for classroom purposes. However, the text is also very appropriate for self-instruction use. Great care has been taken in presenting explanations clearly and in giving easy to follow procedural steps in solving examples. One or more examples are given for each mathematical concept presented. Throughout the book, practical application examples from various occupations are shown to illustrate the actual on-the-job uses of the mathematical concept. Students often ask, "Why do we have to learn this material and of what actual practical value is it?" This question was constantly kept in mind in writing the book and every effort was made to continuously provide an answer.

An understanding of mathematical concepts is emphasized in all topics. Much effort was made to avoid the mechanical *plug in* approach often found in vocational related textbooks. A practical rather than an academic approach to mathematics is taken. Derivations and formal proofs are not presented; instead, understanding of concepts followed by the application of concepts in real situations is stressed.

Section I, Fundamentals of General Mathematics contains the prerequisites for the subsequent sections. It is assumed that students using this book have previously studied the topics presented in Section I; therefore the material in Section I is structured differently than that of the rest of the text. The approach taken is that of treating the topics entirely as review material. Mathematical procedures are not presented in this section, rather an example of the concept is given followed by student exercises and problems. It is felt that the topics, exercises, and problems presented in Section I are of value to the instructor and students for diagnostic and placement testing purposes.

Student exercises and applied problems immediately follow the presentation of concept and examples. In addition, exercises and occupationally related problems

are included at the end of each unit. The book contains a sufficient number of exercises and problems to permit the instructor to selectively plan assignments.

The Solutions and Tests Booklet contains the complete solutions to many problems, the answers to all problems, and a set of section achievement reviews developed for each of the six sections. The achievement reviews are comprehensive and are designed to measure students' achievement of all of the unit objectives contained within each section.

Illustrations, examples, exercises, and practical problems expressed in metric units of measure are a basic part of the content of the entire text. Emphasis is placed on the ability of the student to think and to work with equal ease with both the English and the metric systems. Tables of equivalent units of measure are contained in the Appendix.

An analytical approach to problem solving is emphasized in the plane geometry, computed measure, and trigonometry sections. The approach is that which is used in actual on-the-job trade and technical occupations applications. Integration of algebraic and geometric principles with trigonometry by careful sequencing and treatment of material also helps the student in solving occupationally related problems.

### About the Author

The author, Robert D. Smith, is presently a faculty member in the Vocational-Technical Education Department at Central Connecticut State College, New Britain, Connecticut. Mr. Smith has had experience in the manufacturing industry as tool designer, quality control engineer, and chief manufacturing engineer. He has also been active in teaching applied mathematics, physics, and industrial materials and processes on the secondary school level. He is the author of Delmar's MATHEMATICS FOR MACHINE TECHNOLOGY and APPLIED GENERAL MATHEMATICS.

Mr. Smith has been involved in several professional organizations in his field of interest, including The American Technical Education Association and The Society of Manufacturing Engineers.

# CONTENTS

## SECTION 1 FUNDAMENTALS OF GENERAL MATHEMATICS

Unit 1	<b>Whole Numbers.</b> .....	1
	Adding whole numbers—Subtracting whole numbers—Multiplying whole numbers—Dividing whole numbers—Combined operations in arithmetic expressions	
Unit 2	<b>Common Fractions.</b> .....	8
	Equivalent fractions—Expressing fractions in lowest terms—Expressing mixed numbers as fractions—Expressing fractions as mixed numbers—Lowest common denominators—Adding fractions, mixed numbers, and whole numbers—Subtracting fractions, mixed numbers, and whole numbers—Multiplying fractions, mixed numbers, and whole numbers—Dividing fractions, mixed numbers, and whole numbers—Order of operations	
Unit 3	<b>Decimal Fractions.</b> .....	19
	Rounding decimal fractions—Expressing common fractions as decimal fractions—Expressing decimal fractions as common fractions—Adding decimal fractions—Subtracting decimal fractions—Multiplying decimal fractions—Multiplying by powers of ten—Dividing decimal fractions—Dividing by powers of ten—Powers of numbers—Roots of numbers—Combined operation expressions	
Unit 4	<b>Percents, Statistical Measure, and Graphs.</b> .....	27
	Expressing percents as decimal or common fractions—Expressing decimal and common fractions as percents—Determining percentage, percent (rate), or base—Measures of central tendency—Measures of spread (Dispersion)—Reading graphs—Drawing graphs	
Unit 5	<b>Measure.</b> .....	36
	Equivalent English units of linear measure—Arithmetic operations with English compound numbers—Equivalent metric units of linear measure—Arithmetic operations with metric lengths—Expressing metric units as English units of linear measure—Expressing English units as metric units of linear measure—Equivalent English units of area measure—Equivalent metric units of area measure—Expressing metric units as English units of area measure—Expressing English units as metric units of area measure—Equivalent English units of volume measure—Equivalent metric units of volume measure—Equivalent English-metric volume measures—Equivalent English units of capacity measure—Equivalent metric units of capacity measure—Equivalent English-metric capacity measures—Equivalent English units of weight measure—Equivalent metric units of weight measure—Equivalent English-metric weight measures	



SECTION 2 FUNDAMENTALS OF ALGEBRA

---

Unit 6	<b>Introduction to Algebra.</b> .....	46
	Symbolism—Algebraic expressions—Evaluation of algebraic expressions	
Unit 7	<b>Signed Numbers.</b> .....	59
	Meaning of signed numbers—The number scale—Operations using signed numbers—Absolute value—Addition of signed numbers—Subtraction of signed numbers—Multiplication of signed numbers—Division of signed numbers—Powers of signed numbers—Roots of signed numbers—Expressing numbers with fractional exponents as radicals—Combined operations of signed numbers	
Unit 8	<b>Basic Algebraic Operations.</b> .....	77
	Definitions—Addition—Subtraction—Multiplication—Division—Powers—Roots—Removal of parentheses—Combined operations	
Unit 9	<b>Simple Equations.</b> .....	107
	Expression of equality—Writing equations from word statements—Checking the equation—Principles of equality—Solution of equations by the subtraction principle of equality—Solution of equations by the addition principle of equality—Solution of equations by the division principle of equality—Solution of equations by the multiplication principle of equality—Solution of equations by the root principle of equality—Solution of equations by the power principle of equality—Transposition	
Unit 10	<b>Complex Equations.</b> .....	134
	Equations consisting of combined operations—Substituting values and solving formulas—Rearranging formulas	
Unit 11	<b>Ratio and Proportion.</b> .....	147
	Description of ratios—Order of terms of ratios—Description of proportions—Direct proportions—Inverse proportions	

SECTION 3 FUNDAMENTALS OF PLANE GEOMETRY

---

Unit 12	<b>Introduction to Plane Geometry.</b> .....	164
	Plane geometry—Axioms and postulates—Points and lines	
Unit 13	<b>Angular Measure.</b> .....	170
	Units of angular measure—Units of angular measure in degrees, minutes, and seconds—Arithmetic operations on angular measure in degrees, minutes, and seconds—Adding angles—Subtracting angles—Multiplying angles—Dividing angles—Expressing decimal degrees as degrees, minutes, and seconds—Simple semicircular protractor—Circle graphs—Bevel protractor with vernier scale—Complements and supplements of scale readings	

<b>Unit 14 Angular Geometric Principles.</b>	194
Naming angles—Types of angles—Angles formed by a transversal —Theorems and corollaries	
<b>Unit 15 Triangles.</b>	207
Types of triangles—Angles of a triangle—Congruent triangles— Proving triangles congruent—The Pythagorean Theorem	
<b>Unit 16 Similar Figures.</b>	227
Similar figures—Similar triangles—Isosceles and equilateral tri- angles	
<b>Unit 17 Polygons.</b>	243
Types of quadrilaterals—Polygons interior and exterior angles	
<b>Unit 18 Circles.</b>	256
Definitions—Circumference formula—Arc length formula—Circles —Circle tangents and chord segments—Angles formed inside and on a circle—Angles outside a circle—Internally and externally tangent circles	
<b>Unit 19 Geometric Constructions.</b>	286
Construction 1. To construct a perpendicular bisector of a line segment—Construction 2. To construct a perpendicular to a line segment at a given point on the line segment—Construction 3. To construct a line parallel to a given line at a given distance— Construction 4. To bisect a given angle—Construction 5. To con- struct tangents to a circle from an outside point—Construction 6. To divide a line segment into a given number of equal parts	

## SECTION 4 MEASUREMENT

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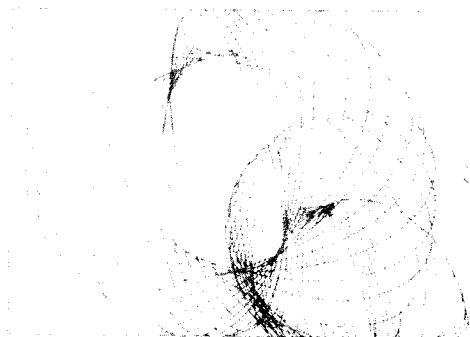
<b>Unit 20 Degree of Precision, Tolerance, Clearance, and Interference.</b>	300
Degree of precision—Common linear measuring instruments— Transfer and comparison measurement—Degree of precision of numbers—Greatest possible error—Tolerance (linear)—Unilateral tolerance—Bilateral tolerance—Mean dimension—Expressing unilateral tolerance as bilateral tolerance	
<b>Unit 21 Steel Rules and Gage Blocks.</b>	323
Types of steel rules—Correct procedure in the use of steel rules— Reading fractional measurements—Measurements that do not fall on rule graduations—Reading decimal-inch measurements— Reading metric measurements—Gage blocks—Determining gage block combinations	



Unit 22	<b>Vernier Instruments: Calipers and Height Gages.</b> . . . . .	341
	Vernier calipers: Types and description—Reading and setting measurements on an English vernier caliper—Reading and setting measurements on a metric vernier caliper—Vernier height gage—Reading and setting measurements on an English vernier height gage—Reading and setting measurements on a metric vernier height gage	
Unit 23	<b>Micrometers.</b> . . . . .	360
	Types of micrometers—Description of an English outside micrometer—Reading and setting an English micrometer—The English vernier micrometer—Reading and setting an English vernier micrometer—Proper care and use of the micrometer—Description of a metric micrometer—Reading and setting a metric micrometer—The metric vernier micrometer—Reading and setting a metric vernier micrometer	
 <b>SECTION 5 COMPUTED MEASURE</b>		
Unit 24	<b>Areas of Common Polygons.</b> . . . . .	380
	Areas of rectangles—Areas of parallelograms—Areas of trapezoids—Areas of triangles given the base and altitude—Areas of triangles given three sides	
Unit 25	<b>Areas of Circles, Sectors, Segments, and Ellipses.</b> . . . . .	404
	Areas of circles—Ratio of two circles—Areas of sectors—Areas of segments—Areas of ellipses	
Unit 26	<b>Prisms and Cylinders: Volumes, Surface Areas, and Weights.</b> . . . . .	419
	Prisms—Volumes of prisms—Cylinders—Volumes of cylinders—Computing altitudes and bases of prisms and cylinders—Surface areas of right prisms and cylinders	
Unit 27	<b>Pyramids and Cones: Volumes, Surface Areas, and Weights.</b> . . . . .	432
	Pyramids—Cones—Volumes of regular pyramids and right circular cones—Computing altitudes and bases of regular pyramids and right circular cones—Surface areas of regular pyramids and right circular cones—Frustums of pyramids and cones—Volumes of frustums of regular pyramids and right circular cones—Surface areas of frustums of regular pyramids and right circular cones	
Unit 28	<b>Spheres and Composite Objects: Volumes, Surface Areas, and Weights.</b> . . . . .	447
	Spheres—Surface area of a sphere—Volume of a sphere—Volumes and surface areas of composite solids	

## SECTION 6 FUNDAMENTALS OF TRIGONOMETRY

Unit 29	<b>Introduction to Trigonometric Functions.</b> . . . . .	457
	Ratio of right triangle sides—Identifying right triangle sides by name—Trigonometric functions: ratio method—Use of trigonometric function tables—The degree-10 minute trigonometric function table—The decimal-degree trigonometric function table—Interpolation using trigonometric function tables	
Unit 30	<b>Trigonometric Functions with Right Triangles.</b> . . . . .	472
	Variations of functions—Functions of complementary angles—Determining an unknown angle when two sides of a right triangle are known—Determining an unknown side when an acute angle and one side of a right triangle are known	
Unit 31	<b>Practical Applications with Right Triangles.</b> . . . . .	484
	Solving problems stated in word form—Solving problems given in picture form which require auxiliary lines—Solving more complex problems which require auxiliary lines	
Unit 32	<b>Law of Sines and Law of Cosines.</b> . . . . .	512
	Cartesian (rectangular) coordinate system—Determining functions of angles in any quadrant—Determining functions of angles greater than $360^\circ$ —Solving oblique triangles—Solving problems given two angles and a side using the Law of Sines—Solving problems given two sides and an angle opposite one of the given sides using the Law of Sines—Solving problems given two sides and the included angle using the Law of Cosines—Solving problems given three sides using the Law of Cosines	
<b>APPENDIX.</b> . . . . .		547
<b>ANSWERS TO ODD-NUMBERED EXERCISES.</b> . . . . .		557
<b>ACKNOWLEDGEMENTS.</b> . . . . .		590
<b>INDEX.</b> . . . . .		591





# SECTION 1

## Fundamentals of General Mathematics

### UNIT 1 Whole Numbers

#### OBJECTIVE

After studying this unit you should be able to

- solve whole number problems by applying the principles of whole numbers.

#### ADDING WHOLE NUMBERS

**Example.** Add and check.  $55\,907 + 12 + 7\,785\,079 + 3\,986$

$$\begin{array}{r} 7\,844\,984 \text{ Ck} \\ 55\,907 \\ 12 \\ 7\,785\,079 \\ + 3\,986 \\ \hline 7\,844\,984 \text{ Ans} \end{array}$$

#### Exercise 1-1

Add and check.

1.  $73 + 24$
2.  $876 + 97$
3.  $4\,397 + 8\,512$
4.  $8\,677 + 12\,393 + 155\,071$
5.  $64 + 178 + 9\,766$

#### SUBTRACTING WHOLE NUMBERS

**Example.** Subtract and check.  $5\,532\,006 - 3\,350\,078$

$$\begin{array}{r} 5\,532\,006 \\ - 3\,350\,078 \\ \hline 2\,181\,928 \text{ Ans} \end{array} \quad \begin{array}{r} 2\,181\,928 \\ + 3\,350\,078 \\ \hline 5\,532\,006 \text{ Ck} \end{array}$$



## 2 SECTION 1 Fundamentals of General Mathematics

### Exercise 1-2

Subtract and check.

1.  $87 - 23$
2.  $978 - 349$
3.  $7\,833 - 626$
4.  $30\,092 - 28\,398$
5.  $438\,078 - 29\,066$

### ADDING AND SUBTRACTING WHOLE NUMBERS IN PRACTICAL APPLICATIONS

#### Exercise 1-3

1. A section of concrete wall and footing is shown in figure 1-1.  
What is the total height of the wall and footing?

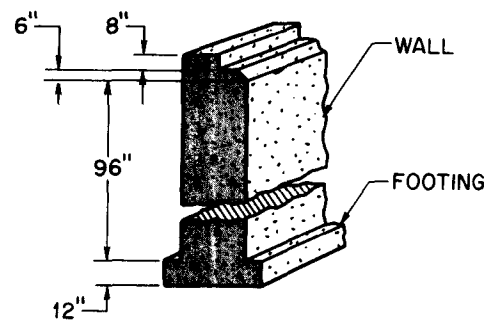


Fig. 1-1

2. During the first week of April, a print shop used the following paper stock: 5 570 sheets on Monday, 7 855 sheets on Tuesday, 7 236 sheets on Wednesday, 6 867 sheets on Thursday, and 6 643 sheets on Friday. During the following week, 4 050 more sheets are used than during the first week. Find the total sheets used during the first two weeks of April.
3. The duplicating machine operator of a manufacturing company makes copies of printed material for various departments within the company. A log is kept to record the number of copies made for each department. The monthly log is shown in figure 1-2.

DEPARTMENT	NUMBER OF COPIES			
	WEEK 1	WEEK 2	WEEK 3	WEEK 4
Production	853	712	956	1 088
Engineering and Design	1 050	936	277	732
Personnel	2 756	1 935	2 080	993
Accounting	830	0	344	130
Sales	1 202	555	3 859	2 444
Data Processing	85	53	0	187
Purchasing	1 932	1 637	767	845
Inspection	177	286	53	0
Receiving and Shipping	538	613	423	778

Fig. 1-2

- a. Find the total number of copies made in week 1.
- b. Find the total number of copies made in week 2.
- c. Find the total number of copies made in week 3.
- d. Find the total number of copies made in week 4.
- e. Find the total number of copies made for the month.

4. An automobile body shop charges \$465 for repairs on a customer's car. The charges for labor are \$196. Paint and materials cost \$67 and replacement parts cost \$110. How much profit is made on the job?
5. A machinist must know dimensions A and B in order to finish grind surfaces F and G of the casting shown in figure 1-3. All dimensions are in millimetres.

- a. Find, in millimetres, dimension A.
- b. Find, in millimetres, dimension B.

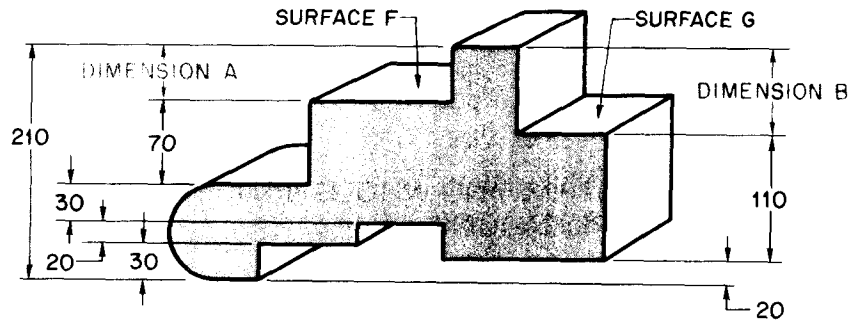


Fig. 1-3

6. A baker makes a batch of cookie mix which weighs 48 pounds. Pastry flour and other ingredients are used to make the mix. The weights of the other ingredients are 13 pounds of almond paste, 12 pounds of margarine, 5 pounds of egg whites, and 7 pounds of granulated sugar. How many pounds of pastry flour are used?

## MULTIPLYING WHOLE NUMBERS

Example. Multiply and check.  $706 \times 315$

$$\begin{array}{r}
 315 \\
 \times 706 \\
 \hline
 1890 \\
 22050 \\
 \hline
 22390 \text{ Ans}
 \end{array}
 \qquad
 \begin{array}{r}
 706 \\
 \times 315 \\
 \hline
 3530 \\
 706 \\
 2118 \\
 \hline
 22390 \text{ Ck}
 \end{array}$$

### Exercise 1-4

Multiply and check.

- $84 \times 76$
- $59 \times 898$
- $305 \times 8756$
- $403 \times 6007$
- $6959 \times 27877$

## DIVIDING WHOLE NUMBERS

Example. Divide and check.  $476947 \div 646$

$$\begin{array}{r}
 738 \text{ R}199 \text{ Ans} \\
 646 \overline{)476947} \\
 \underline{4522} \phantom{00} \\
 2474 \phantom{00} \\
 \underline{1938} \phantom{00} \\
 5367 \phantom{00} \\
 \underline{5168} \phantom{00} \\
 199
 \end{array}
 \qquad
 \begin{array}{r}
 738 \\
 \times 646 \\
 \hline
 4428 \\
 2952 \\
 4428 \\
 \hline
 476748 \\
 + 199 \\
 \hline
 476947 \text{ Ck}
 \end{array}$$

## Exercise 1-5

Divide and check.

1.  $365 \div 5$
2.  $4\,800 \div 16$
3.  $46\,877 \div 5$
4.  $56\,107 \div 79$
5.  $58\,218 \div 836$

MULTIPLYING AND DIVIDING WHOLE NUMBERS  
IN PRACTICAL APPLICATIONS

## Exercise 1-6

1. A building contractor orders 25 lengths of channel iron and 18 lengths of I beam as shown in figure 1-4. What is the total length of channel iron and I beam ordered?

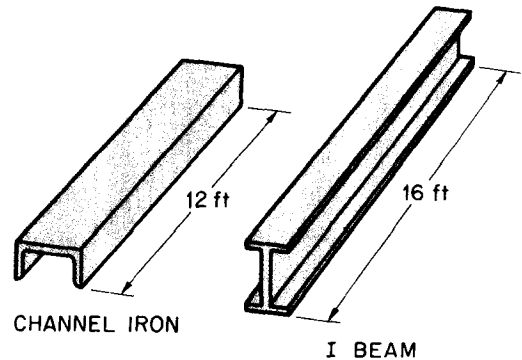


Fig. 1-4

2. The invoice shown in figure 1-5 is mailed to the Center Sports Shop by a billing clerk of the M & N Sports Equipment Manufacturing Company. (An invoice is a bill sent to a retailer by a manufacturer or wholesaler for merchandise purchased by the retailer.) The extension shown in the last column of the invoice is the product of the number (quantity) of units multiplied by the price of one unit. Find the extension amount for each item on the invoice and add the extensions to determine total cost.

	QUANTITY	UNIT	UNIT PRICE	DESCRIPTION	EXTENSION
a.	15	dozen	\$ 2	Floats	\$30
b.	24	each	\$11	Fishing rods	
c.	1	box	\$18	Spools of line	
d.	18	each	\$ 7	Reels	
e.	36	each	\$ 5	Baseball bats	
f.	5	box	\$36	Baseballs	
g.	24	package	\$ 6	Golfballs	
h.	15	each	\$14	Putters	
i.	Total Cost				

Fig. 1-5

3. The drill jig shown in figure 1-6 is laid out by a machine drafter. All dimensions are in centimetres.

- Find, in centimetres, dimension A.
- Find, in centimetres, dimension B.
- Find, in centimetres, dimension C.

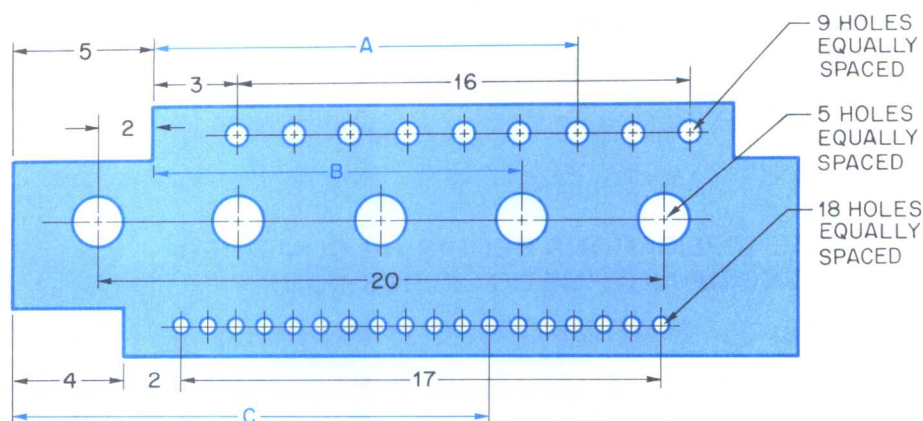


Fig. 1-6

4. Figure 1-7 shows the front view of a wooden counter that is to be built for a clothing store. All pieces of the counter except the top and back are to be made of the same thickness and width of lumber. How many total feet ( $1' = 12''$ ) of lumber should be ordered for this job? Do not include the top or back. Allow 6 feet for waste.

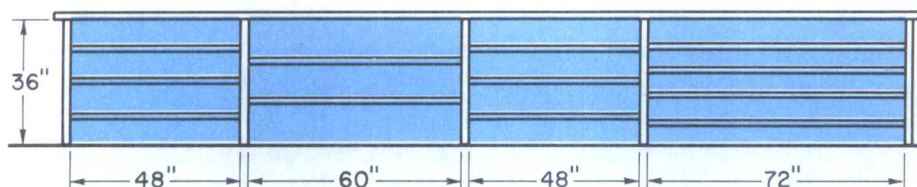


Fig. 1-7

- An 8-pound cut of roast beef is to be medium roasted at  $350^{\circ}\text{F}$ . Total roasting time is determined by allowing 15 minutes roasting time for each pound of beef. If the roast is placed in a preheated oven at 2:00 PM, at what time should it be removed?
- A designer fashions a dress which is 46 inches long from the neck to the hem. The first button is placed one inch from the top; the last button is placed 3 inches from the hem. The buttons are placed 2 inches apart. How many buttons are required?

## COMBINED OPERATIONS IN ARITHMETIC EXPRESSIONS

### Order of Operations

- First, do all operations within grouping symbols. Grouping symbols are parentheses ( ), brackets [ ], and braces { }.
- Next, do multiplication and division operations in order from left to right.
- Last, do addition and subtraction operations in order from left to right.

**Example.** Find the value of  $(15 + 6) \times 3 - 28 \div 7$ .

$$(15 + 6) \times 3 - 28 \div 7$$

$$21 \times 3 - 28 \div 7$$

$$63 - 4$$

**59 Ans**



## Exercise 1-7

Perform the indicated operations.

1.  $9 + 12 - 5$
2.  $35 + 30 \div 5$
3.  $(35 + 30) \div 5$
4.  $(10 \times 8) \div (5 \times 4)$
5.  $(240 - 80) \times 15 \div 3$

### PRACTICAL APPLICATIONS REQUIRING COMBINED OPERATIONS OF ARITHMETIC EXPRESSIONS

## Exercise 1-8

1. An engine is used to lift heavy crates on the truck loading platform shown in figure 1-8. The horsepower needed to lift crates can be found using this formula.

$$hp = (f \times d \div t) \div 550 \quad \text{where } hp = \text{horsepower}$$

$$f = \text{force in pounds}$$

$$d = \text{distance in feet}$$

$$t = \text{time in seconds}$$

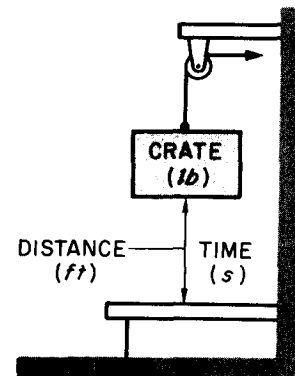


Fig. 1-8

The force is equal to the weight of a crate. The distance is the number of feet a crate is lifted. The time is the number of seconds needed to lift the crate a certain distance. Find the number of horsepower needed to lift each of the crates listed in figure 1-9.

CRATE	WEIGHT OF CRATE	DISTANCE LIFTED	TIME	HORSE-POWER
A	660 lb	10 ft	4 s	
B	1 100 lb	12 ft	6 s	
C	1 650 lb	14 ft	7 s	
D	3 300 lb	8 ft	16 s	
E	2 640 lb	10 ft	8 s	

Fig. 1-9

2. The accountant for a small manufacturing firm computes the annual depreciation of each piece of tooling, equipment, and machinery in the company. From a detailed itemized list, the accountant groups all items together that have the same life expectancy (number of years of usefulness) as shown in figure 1-10. Find the annual depreciation for each group and the total annual depreciation of all tooling, equipment and machinery, using the straight line formula.

*Annual Depreciation = (cost - final value) ÷ number of years of usefulness.*

	GROUP	COST	FINAL VALUE	NUMBER OF YEARS OF USEFULNESS	ANNUAL DEPRECIATION
a.	Tooling	\$14 500	\$1 200	5 years	
b.	Equipment	\$28 350	\$3 750	6 years	
c.	Equipment	\$17 900	\$2 040	10 years	
d.	Machinery	\$67 700	\$7 940	8 years	
e.	Machinery	\$80 300	\$10 600	10 years	
f.	Total Annual Depreciation				

Fig. 1-10

3. A landscaper contracts to provide topsoil and to seed and lime the parcel of land shown in figure 1-11. In order to determine labor and material costs, the landscaper must first know the total area of the land. Find the total area in square feet.

$$\text{Total Area (square feet)} = l \times w + (a \times b) \div 2$$

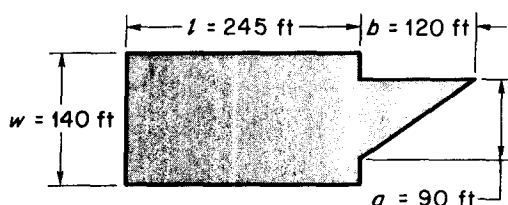


Fig. 1-11

4. The formula called Young's Rule is used in the health field to determine a child's dose of medicine.

$$\text{Child's dose} = (\text{Age of child}) \div (\text{Age of child} + 12) \times \text{average adult dose}$$

What dose (number of milligrams) of morphine sulfate should be given to a 3-year-old child if the adult dose is 10 milligrams?