A Programmed Review Of Engineering Fundamentals

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VNR VAN NOSTRAND REINHOLD COMPANY
NEW YORK CINCINNATI ATLANTA DALLAS SAN FRANCISCO
LONDON TORONTO MELBOURNE

Van Nostrand Reinhold Company Regional Offices:
New York Cincinnati Atlanta Dallas San Francisco

Van Nostrand Reinhold Company International Offices:
London Toronto Melbourne

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Library of Congress Catalog Card Number: 78-1823
ISBN: 0-442-20239-3

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Manufactured in the United States of America

Published by Van Nostrand Reinhold Company
135 West 50th Street, New York, N.Y. 10020

Published simultaneously in Canada by Van Nostrand Reinhold Ltd.

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging in Publication Data

Baldwin, Allen J.
A programmed review of engineering fundamentals.

Includes index.
1. Engineering–Programmed instruction.
2. Engineering–Examinations, questions, etc.
I. Hess, Karen M., 1939– joint author. II. Title.
TA159.B34 620'.007'7 78-1823
ISBN 0-442-20239-3

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Preface

Engineering registration is accelerating at a pace unequalled since institution of registration laws in the 1920s and 1930s. This phenomenon is not due to an easing of entrance requirements, since only vestiges of "grandfathering" and eminence exist in most states. Nor is it due to a lessening in the difficulty of the registration examinations. In fact, it is generally agreed that the Engineering Fundamentals Examination has significantly increased in difficulty over the last fifteen years.

Why then the increased interest in registration among practicing engineers?

Historically the professional engineer has been in private practice offering consulting services directly to the public. Registration laws were passed to protect the public from incompetent, untrained practioners in any engineering area. However, the registration laws go beyond establishing an individual's credentials. One reason for the new interest in engineering registration is the proliferation of new activity areas such as pollution control and energy conservation where the public is keenly aware of and insistent upon quality technological inputs.

A second reason for the increased interest in registration also relates to the consumer movement. Registration laws in most states do *not* apply to manufacturers. This so-called industry exemption is under attack by consumers who are concerned about unsafe products designed by anonymous employees of a corporation subject to no public control over their level of competence. Because of this consumer concern, many large firms are strongly encouraging their engineers to become registered so that in any possible lawsuit involving a firm its employees can appear in court as professionals.

Further, engineers themselves are becoming more aware that licensure is a necessary requirement of a profession, a key factor in the control *of* the profession *by* the profession. Without licensure, such other control mechanisms as school accreditation, entrance requirements, and continuing education are ineffective: anyone can practice without conforming to these controls.

Finally, reciprocity among states has become a reality. In the past each state gave its own examination; there was little or no reciprocity. Now, however, the National Council of Engi-

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neering Examiners (NCEE) has instituted a national examination in virtually all states. This book is designed as a study aid for the NCEE Engineering Fundamentals Examination.

Prerequisites for the Examination

The prerequisite for admission to the Engineering Fundamentals Examination is usually graduation from an accredited engineering college. Application is made to the local state board of registration. The exams are usually given twice yearly, in November and April; the fee varies from state to state.

The Engineering Fundamentals Examination

The examination is an open-book, eight-hour, written exam given in two four-hour parts.

Part I is usually open-book, multiple-choice. The examinee answers as many questions as he can from the following distribution.

Mathematics	15%
Nucleonics and wave phenomena	3%
Chemistry	9%
Statics	9%
Dynamics	9%
Mechanics of materials	9%
Fluid mechanics	9%
Thermodynamics	12%
Electrical theory	12%
Materials science	5%
Economics	8%

Part II is usually open-book problem solving. It consists of three problems each in seven subjects:

Dynamics
Mechanics of materials
Thermodynamics
Electrical theory
Statics
Fluid mechanics
Economics analysis

The Part II problems consist of introductory information about a problem situation, followed by ten multiple choice questions concerning the problem. Typically the applicant selects five of the twenty-one problems in accordance with the following rules:

1. The five problems must be distributed among at least four subjects.
2. Not more than one problem can be selected in economics.

Each state can and often does change the above rules slightly. The examinee should carefully study the rules in effect at the time and place of the examination. The rules listed above are meant as guidelines for preparing to take the exam.

This Text

This text had its inception in a professional society study conducted in 1969 to find ways to help and encourage engineers to become registered. It became clear that a graduating senior from an accredited school usually had little difficulty passing the Engineering Fundamentals Examination, but approximately half of those taking the examination had been away from the academic environment for several years. For this mature engineer, little help was available. As a result, a refresher course was initiated to assist the engineer with several years of experience prepare for the fundamentals examination.

This text is an outgrowth of the experience gained from the refresher course from 1969 to the present. The text has been prepared to closely simulate the multiple-choice questions in the national examination. The questions are similar in scope and content to those in both Parts I and II of the exam.

Each chapter presents a brief summary of the chapter's content, followed by basic textual material related to specific concepts and principles. The key concepts, boxed for clarity, are followed by examples and one or two application problems for you to work. The answers to the problems are given immediately after each problem, providing you with an immediate indication of your understanding of each concept.

How to Use This Book

Work through the book in sequence. However, if some material in the first section is too basic, skip it. For most the basic drill in mathematics pays off in later chapters.

Use your own reference tables and charts. These have purposely been omitted from this text as you should have access to and be familiar with basic reference tables and charts during the examination if it is open-book in your state.

Use your reference books to look up any terms and definitions which you do not understand in this text. All terms and definitions cannot be contained in a single text. However, the basic principles you will need to pass the exam are included.

Do *not* skip the "afternoon set" problems presented at the end of each chapter in the second section. These problems are typical of those contained in Part II of the exam and constitute one-half of the exam.

Do not elect in advance to skip certain subjects. This will limit your options when you take the exam. You may be an electrical engineer, but the exam may contain some very easy questions in thermodynamics which you should answer.

Always check you answers with those given. Certain mistakes are commonly made on some problems. In these cases the wrong answer is included among the choices. You will then be led to believe you have the right answer when, in fact, you are wrong. If this happens to you, go back to see where you have made your error and why the right answer is right.

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Part I Mathematics and Science

Part I of this book reviews the basic mathematics and science principles covered in the morning session of the National Engineering Fundamentals Examination. Since the morning session problems are in multiple-choice format, this book also presents the problems in multiple-choice format.

1 Algebra

Discussion of and problems related to conversion, factoring, quadratic equations, combining exponents, scientific notation, simultaneous equations, determinants, simultaneous equations, logarithms, and laws of logarithms.

A. DEFINITION

Algebra provides tools for converting a problem from the English language into mathematical language. Thus, it is more powerful than ordinary arithmetic. The basic tool of algebra is the *equation.* An equation is a statement of fact, a truism. The equal sign (=) in algebra corresponds to the word *is* in the English language.

The English word *is* is equivalent to the algebraic equal sign (=).

Example

The English phrase, "The engine produces 50 horsepower" is written algebraically as Hp = 50.

PROBLEMS

1. The Greek mathematician Euclid, lacking algebra, said in 300 B.C.: "The circumference of a circle is 3.141592 times its diameter." State this truism in the language of algebra:

2. Sir Isaac Newton said: "The acceleration of a body is proportional to the force acting on it and inversely proportional to its mass." What is the algebraic equation? (Circle the letter of the correct response.)

   a. $F = ma$. b. $a \propto F/m$. c. $S = \frac{1}{2}at^2$. d. $F \propto am$. e. $a \propto Fm$.

   Check your answers with those which follow.

Answers

1. (Circumference) = (3.141592) X (Diameter) OR $C = \pi D$.
   The word *is* is equivalent to =. The word *times* is equivalent to X.
2. b.
   The word *proportional* is the same as the word *is* if the units of the variables are correct. You may want to check the dictionary for the meaning of "inversely proportional."

B. CONVERSION–INDEPENDENT AND DEPENDENT VARIABLES

The first step in solving a problem using algebra is to *convert* the nouns (things) in the problem into algebraic symbols. The convention is to use the letters in the first half of the alphabet (a, b, c, etc.) for things that have *known* values. These are called *independent variables* because their values are fixed and not influenced by the problem. The letters in the last half of the alphabet (u, v, w, x, y, z) are reserved for things that have *unknown* values. These are *dependent variables* because their values are determined by the problem itself.

Independent variables are the values given in the problem–knowns.
Dependent variables are controlled by the circumstances of the problem–unknowns.

Example

The sum of two numbers is 18. One number is double the other. The sum is an independent variable: $a = 18$. The numbers are dependent variables: $x = ?$ $2x = ?$

The equation relating the variables is:

$$x + 2x = a$$
$$3x = 18$$
$$x = 18/3.$$

The numbers are:

$$x = 6$$
$$2x = 12.$$

PROBLEMS

1. °F = 9/5 °C + 32.
   The Celsius temperature is 10° (independent variable).
   What is the Fahrenheit temperature (dependent variable)?

   a. -40°F. b. 128°F. c. 50°F. d. 100°F. e. -459°F.

2. The velocity of car *A* is 50 mph, north.
   The velocity of car *B* is 60 mph, south.
   A is 165 miles south of *B*. How long until they meet?

   a. 1 hr 25 min. b. 1 hr. c. 2 hrs. d. 1 hr 30 min. e. 2 hrs 20 min.

   Check your answers with those which follow.

Answers

1. c.
2. d.
   If your answers are not correct, review the definition of *algebra*, p. 3.

C. FACTORING

Manipulation such as that in the previous problems is subject to rules based on the form of the equation. The first step in solving a problem is to rearrange the equation into its simplest form. This is called *factoring*.

Forms of Equations:
Linear: $x = a$
Quadratic: $x^2 = b$
nth-degree polynomial: $x^n = c$
General form of a third degree polynomial

$$c_3x^3 + c_2x^2 + c_1x^1 + c_0x^0 = 0$$

Example

To simplify the equation $ax + bx = c$:
combine the coefficients of x: $x(a + b) = c$;
divide both sides by $(a + b)$:

$$x\frac{(a+b)}{(a+b)} = \frac{c}{(a+b)}.$$

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