

INTRODUCTION TO **INDUSTRIAL ENGINEERING**

SECOND EDITION



Avraham Shtub • Yuval Cohen



CRC Press
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A Firsthand Look at the Role of the Industrial Engineer

The industrial engineer helps decide how best to utilize an organization's resources to achieve company goals and objectives. **Introduction to Industrial Engineering, Second Edition** offers an in-depth analysis of the industrial engineering profession. While also providing a historical perspective chronicling the development of the profession, this book describes the standard duties performed, the tools and terminologies used, and the required methods and processes needed to complete the tasks at hand. It also defines the industrial engineer's main areas of operation, introduces the topic of information systems, and discusses their importance in the work of the industrial engineer.

The authors explain the information system concept, and the need for integrated processes, supported by modern information systems. They also discuss classical organizational structures (functional organization, project organization, and matrix organization), along with the advantages and disadvantages of their use. The book includes the technological aspects (data collection technologies, databases, and decision-support areas of information systems), the logical aspects (forecasting models and their use), and aspects of principles taken from psychology, sociology, and ergonomics that are commonly used in the industry.

What's New in This Edition

The second edition introduces fields that are now becoming a part of the industrial engineering profession, alongside conventional areas (operations management, project management, quality management, work measurement, and operations research). In addition, the book:

- Provides an understanding of current pathways for professional development
- Helps students decide which area to specialize in during the advanced stages of their studies
- Exposes students to ergonomics used in the context of workspace design
- Presents key factors in human resource management
- Describes frequently used methods of teaching in the field
- Covers basic issues relative to ergonomics and human-machine interface
- Introduces the five basic processes that exist in many organizations

Introduction to Industrial Engineering, Second Edition establishes industrial engineering as the organization of people and resources, describes the development and nature of the profession, and is easily accessible to anyone needing to learn the basics of industrial engineering. The book is an indispensable resource for students and industry professionals.



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To my wife Ailona Shtub—Avi Shtub

To my family—Yuval Cohen

Preface

This book presents the major tasks performed by industrial engineers, and the tools that support these tasks. The focus is on the organizational processes for which these tasks are needed, and the terminology used to describe the tasks, tools, and processes. The tools discussed here are basic tools that do not require in-depth knowledge of mathematics, statistics, psychology, or sociology. The book also examines the role of the industrial engineer in the production and service sectors. The intention is to help new students understand current pathways for professional development, and help them decide in which area to specialize during the advanced stages of their studies.

This book delineates the broad scope of areas in which industrial engineers are engaged, including areas that became part of industrial engineering (IE) in recent decades such as information systems, supply chain management, and service engineering. These fields are becoming an important part of the IE profession, alongside the traditional areas of IE such as operations management, project management, quality management, work measurement, and operations research. Industrial engineers require a strong understanding and good knowledge in all of these fields in order to perform their tasks.

This book contains the following chapters.

Chapter 1. Introduction

Here we discuss the nature of the IE profession and provide answers to basic questions such as

- What is engineering?
- What is IE?
- What is the IE profession?
- How do you acquire this profession?

Other points covered in this chapter are

- The system concept and its implementation in manufacturing and service.
- Tools needed by industrial engineers in order to perform their jobs.
- Frequently used methods of teaching in this field.

To give students a historical perspective, we show the development of the profession from its early days until recent years. Today, the profession must take into consideration the intense competition in industry due to globalization. Elements of competition include

- Cost reduction
- Shortening delivery times—time-based competition
- Quality improvement
- Achieving maximum flexibility

These elements of competition are the essence of the challenge facing industrial engineers. They are charged with designing systems and organizations that not only survive in the global competitive environment but also succeed.

Chapter 2. Organizations and Organizational Structures

This chapter deals with the organization of people and resources in order to achieve organizational goals. The chapter begins by explaining the need for a well-designed organization of human resources. Classical organizational structures are presented as

- Functional organization
- Project organization
- Matrix organization

Relative advantages and disadvantages of each of these organizational types are discussed, with an emphasis on communication, responsibility, and authority as tools for achieving a competitive advantage.

The discussion leads to the question of which organizational structure is best for today's competitive environment and the conclusion is that the organization must be (1) modern, (2) process based, and (3) supported by an appropriate information system. These three conditions are essential for success.

In addition to the organization of human resources, other resources such as production resources must also be efficiently organized. Production resources are mainly machines and equipment such as material handling equipment. The chapter reviews different layouts used to organize these resources:

- Flow shop

- Job shop
- Cells of group technology-based layout

Advantages and disadvantages of these layouts are discussed, alongside a survey of the fixed location layout where people, material, and equipment are transported to the place of work. This layout is quite common in nonrepetitive environments or projects such as home or ship building.

The relationship between the organizational structure and equipment layout leads to a discussion on processes in production and services and how these processes should be organized.

Chapter 3. Project Management

This chapter discusses organizations that perform projects (i.e., nonrepetitive undertakings). The discussion opens with a mapping of a project's stakeholders and understanding their needs and expectations from the project. Needs and expectations are translated into a conceptual design, using special decision-making tools to choose between technological and operational alternatives. Analysis of the cost/benefit/risk and time is discussed and the appropriate analytical tools are presented. A review of the project life cycle serves as a guideline for displaying methods for scheduling, budgeting, management, and control of projects, with emphasis on the relatively simple methods used in the industry.

The discussion of project management leads to discussion on information and its use—especially, turning data into information that supports decision making.

Chapter 4. Information and Its Uses

This chapter extends the discussion on data and information. It examines data collection, storage, retrieval, and processing, and using appropriate models to create the information necessary to support decision making.

The discussion emphasizes the following topics:

- Quality of information
- Data collection methods and how to use raw data to create useful information
- How to forecast future data

The chapter aims to develop a basic understanding of the nature of information systems, decision support systems, and database systems. We show the relationship between the knowledge base and models used to analyze data and to support decision-making processes.

Chapter 5. Marketing Considerations

This chapter is the first in a series of two chapters focusing on the interface between the industrial engineer and other professionals within the organization. This chapter deals with the customers, while the following chapter deals with suppliers and subcontractors. We present the tool that links production to marketing—the Master Production Schedule—and discuss the relationship between inventory and delivery times. The chapter introduces the classic dilemma between having high levels of inventory (for which a price must be paid) and the resulting shorter delivery times and lower inventory levels causing longer lead times. We discuss some policies including

- Make to stock
 - Make to order
 - Assemble to order
 - Design/engineer to order
-

Chapter 6. Purchasing and Inventory Management

The industrial engineer must understand the organization's relationship with suppliers and subcontractors. Procurement is important in the competitive world, and this chapter discusses some key points of this topic:

- What to buy from suppliers and subcontractors and what to make in house—the make or buy problem.
- If the decision is to buy, how to find suitable suppliers to form a list of candidates.
- How is a supplier chosen from the list of suitable suppliers?
- How to manage the relationship with the supplier over time.

When it comes to purchasing materials, inventory management issues are also important such as

- How often to order?
- What quantity to order?
- What are the costs associated with inventories?
- What are the advantages in maintaining inventories?

Resolving these issues is not simple, and there is a need for decision support tools. This chapter presents the basic models and the assumptions underlying each model.

Some purchasing decisions are repetitive, and some are not. How these decisions are made and how to take advantage of procurement and inventory to achieve competitive advantage are the main subjects of this chapter.

Chapter 7. Scheduling

This chapter focuses on scheduling the organization's operations. Scheduling an organization's operations is dependent both on marketing and the interface with customers (Chapter 5) and on procurement and the interface with suppliers (Chapter 6).

Scheduling issues exist in both manufacturing and service systems. Competition drives many scheduling goals and constraints. After setting scheduling goals and constraints, the industrial engineer has to select the right scheduling method.

Our discussion starts with scheduling of the job shop. Next, we discuss the scheduling of the flow shop, and finally we present a general discussion about scheduling, using a concept of the Toyota production system (TPS): Just In Time (JIT), and we also discuss the Theory of Constraints (TOC) that focuses on scheduling bottlenecks.

We explain the logic of simple scheduling methods and provide examples highlighting the effectiveness, advantages, and disadvantages of these methods.

Chapter 8. Material Requirements Planning

This chapter introduces the basic computerized approach for managing production and procurement of material. Material requirements planning (MRP) was developed in the 1970s when the price of computers dropped enough for commercial organizations to be able to buy them. The method

is based on simple logic and common processing of data from multiple files including

- The bill of material (BOM) file
- Inventory files
- The master production schedule (MPS)

Processing these files enables detailed planning and coordination between procurement and manufacturing activities. MRP logic comprises several components such as

- Gross to net
- Time phasing
- Lot sizing

MRP systems are the basis for planning and management of material in many organizations. It is important that industrial engineers understand, early on in their studies, the logical principles underlying these systems.

The discussion in this chapter reveals the weakness of the first generation MRP systems, which did not include mechanisms for planning production capacity. Solutions to this problem were developed later in the form of rough-cut capacity planning and capacity requirement planning (CRP).

Chapter 9. Enterprise Resource Planning

This chapter presents a framework of the information systems that manage the entire enterprise: enterprise resource planning (ERP) systems.

ERP systems are advanced organizational information systems, and many organizations have implemented them.

Industrial engineers play a major role in implementing these systems. Their tasks include, among others:

- Setting the system requirements
- Defining organizational processes
- Choosing the suitable system for the organization
- Recruiting participants
- Implementing the ERP system

We explain the principles of ERP systems and discuss their selection and implementation.