industrial robots and robotics

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Industrial Robots and Robotics

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To my father, Abraham
and my friends, Alicia and Phillip.
Edward Kafrissen

and

In memory of my friend, Louis Fridovich.
This book is also dedicated to
his wife, Sylvia, and
his children, David, Bernard, and Irwin.

Mark Stephans

Preface

This text has been written for an introductory course in robots and robotics to be used in community or senior colleges as an elective course.

Chapter 1 gives an overview of industrial robots for today and tomorrow. Chapter 2 treats the concept of computers and microprocessors used in robot and robotic work. Servo control systems of robot comprise Chapter 3. How the actuator of a robot converts hydraulic, electrical, and pneumatic energy to effect the motion of the robot is explained in Chapter 4. Chapter 5 takes up robotic transducers including resolvers, encoders, and other sensors, followed by data acquisition and conversion systems. Chapter 6 includes harmonic drives, ball bearing screws, shock absorbers, and other systems. Chapter 7 takes up the important topic of robotic vision. Chapter 8 includes practical industrial robots, specifications, programming, and applications. Chapter 9 emphasizes robot software including program language for robots. Chapter 10 concentrates on setting up robotic work cells. Chapter 11 highlights the justification and implications of economics and growth in robotics. The appendixes include robot terminology, robot manufacturers, Air Force and Army robotic programs, a general bibliography, and other information useful in robotic work and study.

This text can also be used as a reference for anyone interested in learning about robots—engineers, manufacturers, and hobbyists. Each chapter ends with problems and references.

The authors have tried to present the material in a logical and consistent fashion. Since this is a relatively new field, many concepts that are presented today may be changing tomorrow.

There will be many jobs in the years to come in robots and robotics. You may be a member of one of the groups that make themselves available for work in the robot technology era whether you are in the electronic, computer, medical, mechanical, or electromechanical field, to name a few areas of interest.

In *The Britannic Review of Development of Engineering Education*, published by Encyclopaedia Britannica, Inc., Lord Kelvin had this to say about measurement and instrumentation:

> I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it. But when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be.

(From Volume 1, page 123, © 1970 by Encyclopaedia Brittanica, Inc.)

People who are interested in robotics will have to learn by experience and apply this technology to better themselves in this thriving new field.

The authors wish to thank Mr. David Ungerer, president; Mr. David Dusthimer; Mr. Greg Michael; Mrs. Linda MacInnes, editorial assistant; Mrs. Ann Mohan, production editor; and the entire crew of Reston Publishing Company. Without their help this project would never have gotten off the ground floor.

The authors would also like to thank Mrs. Betty Johnson, who typed the original manuscript, and express condolence on the accidental death of her 22-year-old son, Eric Johnson.

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Mark Stephans

Acknowledgments

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Industrial Robots and Robotics

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Industrial Robots Today and Tomorrow: An Overview

1.1 Introduction

In the early 1960s, George Devol and Unimation Incorporated introduced the first industrial robot. The basic concept was to build a machine that was flexible enough to do a variety of jobs automatically, a device that could be easily taught or programmed so that, if the part or process changed, the robot could adapt to its new job without expensive retooling, as was the case with hard automation. It was this mating of a computer to a flexible manipulator that helped to open the door to new methods of manufacturing.

James S. Albus, in a recent book on the effect of computers and robots, wrote

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Text and diagrams for Chapter 1 are in part based on material supplied by Jerome W. Saverino, Vice-President, Marketing and Applications, LTI Technology, Suite 701, 2701 Toledo St., Torrence, Calif. 90503.

From Jerry W. Saveriano, "Industrial Robots Today and Tomorrow," *Robotics Age Magazine*, Summer 1980, Vol. 2, No. 2. Reprinted with permission of Robotics Age, Inc., 174 Concord Street, Peterborough, N.H. 03458.

> The human race is now poised on the brink of a new industrial revolution which will at least equal, if not far exceed, the first Industrial Revolution in its impact on mankind. The first Industrial Revolution was based on the substitution of mechanical energy for muscle power. The next industrial revolution will be based on the substitution of electronic computers for the human brain in the control of machines and industrial processes.[1]

Recent advances in microprocessor technology, the increasing need to improve productivity, and the long-range goal of computer-controlled, unmanned manufacturing plants have provided new impetus for industry to apply robots in manufacturing. *Fortune Magazine,* in its December 17, 1979, issue, stated, "The number of industrial robots in use in the United States has more than doubled in the past three years. The industry's sales have been growing at an annual rate of thirty-five percent."[2] Ten years from now, sales in the United States are expected to total over $5 billion.

In 1982, there was on the order of 6000 robots and robotic devices in use in the American industry. By 1985, the projected number increases to about 20,000 in use in the United States. In 1995, the automated manufacturer and the plastic processors will use around 200,000 industrial robots and robotic devices.

Estimates of the total number of industrial robots and robotic devices in use throughout the world in 1982 include 6000 in the United States, 5000 in Europe, and approximately 30,000 in Japan. Thus approximately 41,000 industrial robots are already in use throughout the world.

Included in the count in Japan are simple robots similar to the Seiko Model 700 shown in Figure 1.1. These types of robot devices have been used in Japan for almost 40 years.

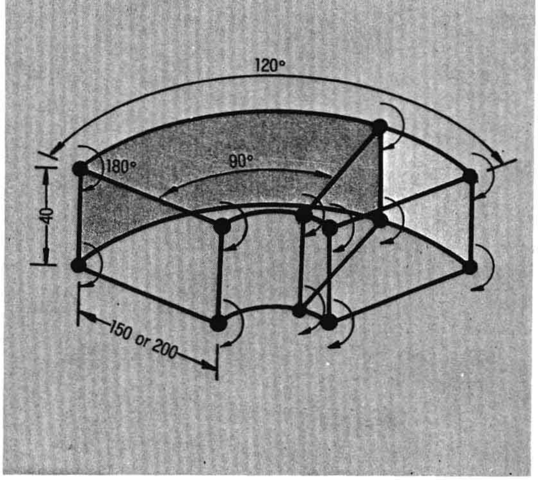
In a paper given to the Japan Industrial Robot Association, the executive director, Kanji Yonemoto, gave this as the general view of robot use in Japan:

> By virtue of their functional characteristics enabling versatile and flexible motions, industrial robots help achieve automation of the small-batch of mixed-line production, thereby contributing greatly to the improvement of productivity.
>
> Utilization of industrial robots brings about a change of the production system from the "man–machine system" to "man–robot–machine system." This change brings socioeconomic impacts such as the improvement of working environments and the humanization of working life, by helping promote industrial safety and advance labor quality, as well as increase returns on investment, stability of product quality, and improvement of production management.[3]

There is little doubt that computers and robots will significantly alter manufacturing in the near future. To gain a better understanding of this exciting and new technology, it is best to start with some fundamentals of robotics and then advance to robot systems.

The Robert robot as shown in Figure 1.2 is a simple two-axis ROBOT designed to teach the principles of Robots. Robert has the following features:

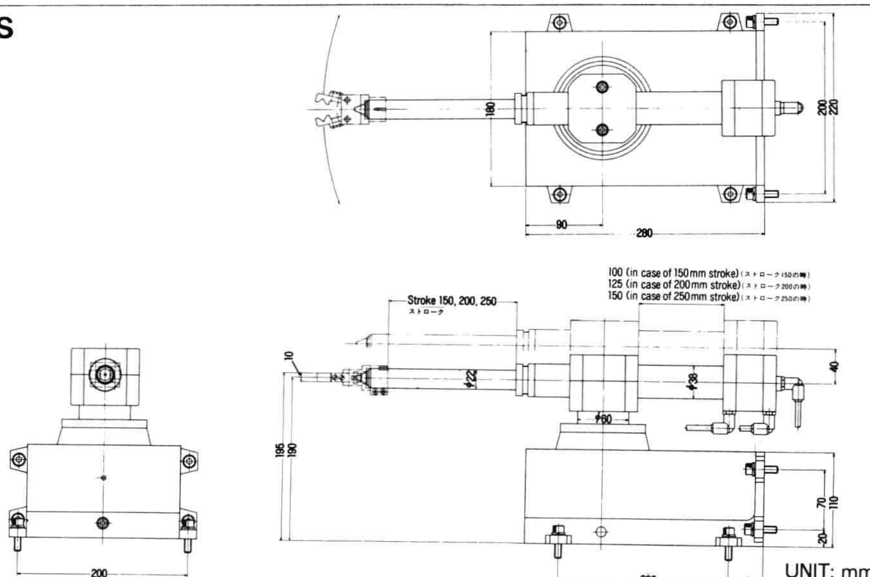
OPERATING RANGE



TECHNICAL DATA

Vertical 垂 直	40 mm (40 mm/0.5 sec)
Horizontal 水 平	$150^{\pm 2.5}$ or $200^{\pm 2.5}$ mm (150 mm/0.5 sec)
Swing 旋 回	$90°^{\pm 2°}$ or $120°^{\pm 2°}$ (clockwise or counterclockwise) (90°/0.5 sec) (正 逆 方 向)
Repeatability 再 現 精 度	±0.025 mm
Payload (incl. gripper) グリッパ含可搬重量	500 g (1000 g at lower speed) (スピードが遅い時1,000g)
Dimensions 寸 法	280 × 220 × 230 mm
Weight 重 量	20 kg
Drive 駆 動	Air pressure normal use 4 kg/cm² (常用空気圧)
Option オプション	Horizontal axis 250 mm long 水 平 軸 Gripper (open + close) (W: 300 g) グリッパ (開+閉)

DIMENSIONS



• *Specifications are subject to change without notice.*

FIGURE 1.1. Specifications for Seiko Model 700, a four-axis air-operated simple robot arm. Courtesy of Seiko Instruments, U.S.A., Inc., Torrence, Calif. [See next page for photo.]