

Mechanics and Control of Robot Manipulators

Chapter 1 Solutions

This manual contains solutions to almost all exercises in Chapters 1 - 9 and solutions to the programming problems for Chapters 2 - 9.

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CHAPTER 1

INTRODUCTION

EXERCISES

1.1) HERE'S JUST AN EXAMPLE OF A REASONABLE RESPONSE: (REF. [6] IN CHAP. 1)

1955 DENAVIT & HARTENBERG DEVELOPED METHODOLOGY FOR DESCRIBING LINKAGES.

1961 GEORGE DEVOL PATENTS DESIGN OF FIRST ROBOT

1961 FIRST UNIMATE ROBOT INSTALLED.

1968 SHAKEY ROBOT DEVELOPED AT S.R.I.

1975 ROBOT INSTITUTE OF AMERICA FORMED.

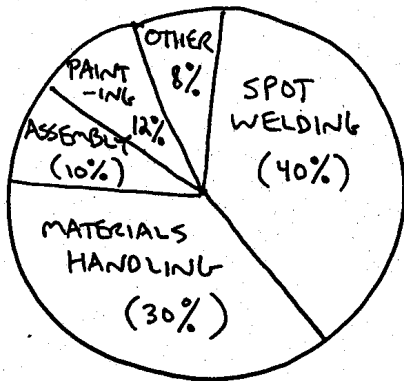
1975 UNIMATION BECOMES FIRST ROBOT CO. TO BE PROFITABLE.

1978 FIRST PUMA ROBOT SHIPPED TO GM.

1985 TOTAL U.S. MARKET EXCEEDS 500 MILLION DOLLARS (ANNUAL REVENUE).

DEVELOPMENTS MIGHT BE SPLIT INTO A TECHNICAL LIST AND A BUSINESS LIST.

1.2)

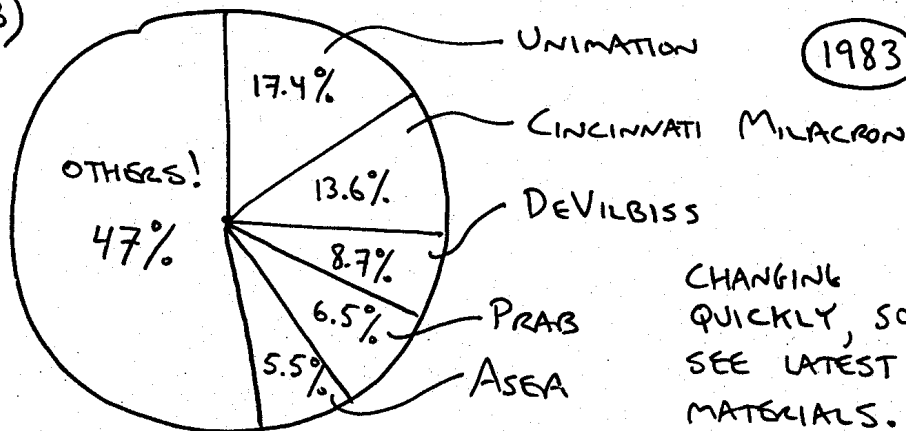


(BASED ON 1981 NUMBERS)

SOURCE:

L. CONIGLIARO, "ROBOTICS PRESENTATION, INSTITUTIONAL INVESTORS CONF.", MAY 28, 1981, BACHE NEWSLETTER 81-249.

1.3)



1983

CHANGING QUICKLY, SO SEE LATEST MATERIALS.

1.4) KINEMATICS IS THE STUDY OF POSITION AND DERIVATIVES OF POSITION WITHOUT REGARD TO FORCES WHICH CAUSE THE MOTION.

WORKSPACE IS THE LOCUS OF POSITIONS AND ORIENTATIONS ACHIEVABLE BY THE END-EFFECTOR OF A MANIPULATOR. TRAJECTORY IS A TIME BASED FUNCTION WHICH SPECIFIES THE POSITION (AND HIGHER DERIVATIVES) OF THE ROBOT MECHANISM FOR ANY VALUE OF TIME.

1.5) FRAME IS A COORDINATE SYSTEM, USUALLY SPECIFIED IN POSITION AND ORIENTATION RELATIVE TO SOME IMBEDDING FRAME. DEGREES OF FREEDOM IS THE NUMBER OF INDEPENDENT VARIABLES WHICH MUST BE SPECIFIED IN ORDER TO COMPLETELY LOCATE ALL MEMBERS OF A (RIGID-BODY) MECHANISM. POSITION CONTROL IMPLIES THE USE OF A CONTROL SYSTEM, USUALLY IN A CLOSED-LOOP MANNER, TO CONTROL THE POSITION OF ONE OR MORE MOVING BODIES.

1.6) FORCE CONTROL IS THE USE OF (USUALLY CLOSED-LOOP) ALGORITHMS TO CONTROL THE FORCES OF CONTACT GENERATED WHEN A ROBOT TOUCHES ITS WORK ENVIRONMENT. A ROBOT PROGRAMMING LANGUAGE IS A PROGRAMMING LANGUAGE INTENDED FOR USE IN SPECIFYING MANIPULATOR ACTIONS.

1.7) SEE REFERENCES. IN 1985 AVERAGE LABOR COSTS OF \$15 TO \$20 ARE REASONABLE DEPENDING HOW FRINGE BENEFITS ARE CALCULATED.

1.8) IT'S INCREASED A LOT! SEE REFERENCES. COMBINE 1.7 & 1.8 ANSWERS TO SEE WHY THE ECONOMICS OF ROBOT USE HAS CHANGED DRAMATICALLY.