INTERNATIONAL STANDARD

ISO 9787

Third edition
2013-05-01

Robots and robotic devices — Coordinate systems and motion nomenclatures

Robots et composants robotiques — Systèmes de coordonnées et nomenclatures de mouvements

Reference number
ISO 9787:2013(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9787 was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 2, *Robots and robotic devices*.

This third edition of ISO 9787 cancels and replaces the second edition (ISO 9787:1999), which has been technically revised. In particular, the scope has been expanded to include robots operating in both industrial and non-industrial environments.

Introduction

This International Standard is one of a series of International Standards dealing with robots and robotic devices, which cover topics including vocabulary, safety, presentation of characteristics, performance criteria and related test methods, and mechanical interfaces. The series of International Standards dealing with robots and robotic devices are interrelated and are related to other International Standards.

Annex A provides examples of applications for different mechanical structures.

Robots and robotic devices — Coordinate systems and motion nomenclatures

1 Scope

This International Standard defines and specifies robot coordinate systems. It also provides nomenclature, including notations, for the basic robot motions. It is intended to aid in robot alignment, testing, and programming.

This International Standard applies to all robots and robotic devices as defined in ISO 8373.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8373:2012, *Robots and robotic devices — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8373 and the following apply.

3.1
configuration
set of all joint values that completely determines the shape of the robot at any time

[SOURCE: ISO 8373:2012, 3.5]

3.2
base mounting surface
connection surface between the arm and its supporting structure

[SOURCE: ISO 8373:2012, 3.9]

3.3
mobile platform
assembly of all components of the mobile robot which enables locomotion

[SOURCE: ISO 8373:2012, 3.18, modified — Notes 1 and 2 have been removed.]

3.4
world coordinate system
stationary coordinate system referenced to earth, which is independent of the robot motion

[SOURCE: ISO 8373:2012, 4.7.1]

3.5
base coordinate system
coordinate system referenced to the base mounting surface

[SOURCE: ISO 8373:2012, 4.7.2]

3.6
mechanical interface coordinate system
coordinate system referenced to the mechanical interface

[SOURCE: ISO 8373:2012, 4.7.3]

3.7
tool coordinate system
TCS
coordinate system referenced to the tool or to the end effector attached to the mechanical interface

[SOURCE: ISO 8373:2012, 4.7.5]

3.8
working space
space which can be swept by the wrist reference point increased by the range of rotation or translation of each joint in the wrist

[SOURCE: ISO 8373:2012, 4.8.4]

3.9
tool centre point
TCP
point defined for a given application with regard to the mechanical interface coordinate system

[SOURCE: ISO 8373:2012, 4.9]

3.10
mobile platform origin
mobile platform reference point
origin point of the mobile platform coordinate system

[SOURCE: ISO 8373:2012, 4.11]

3.11
task coordinate system
coordinate system referenced to the site of the task, denoted by O_k - X_k - Y_k - Z_k

[SOURCE: ISO 14539:2000, 3.3.5]

3.12
object coordinate system
coordinate system referenced to the object, denoted by O_j - X_j - Y_j - Z_j

[SOURCE: ISO 14539:2000, 3.3.6]

3.13
camera coordinate system
coordinate system referenced to the sensor which monitors the site of the task, denoted by O_c- X_c- Y_c- Z_c

Note 1 to entry: A vision system may be installed to detect the position and orientation of arbitrarily placed objects.

[SOURCE: ISO 14539:2000, 3.3.7]

3.14
grasp-type gripper
gripper that handles an object with finger(s)

[SOURCE: ISO 14539:2000, 4.1.2.1]

4 General rules for coordinate systems and motion nomenclature

4.1 Right-hand coordinate systems

All coordinate systems described in this International Standard are defined by the orthogonal right-hand rule as shown in Figure 1.

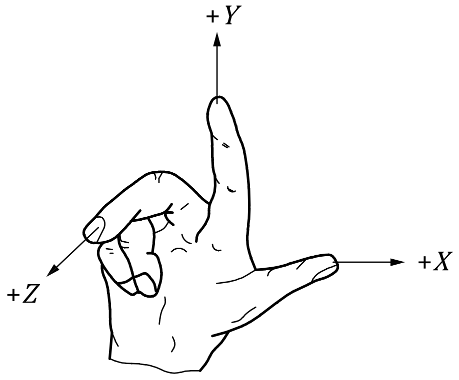


Figure 1 — Right-hand coordinate system

4.2 Translations

Translations along *X*, *Y*, and *Z* axes are expressed in the following way:

+ or – *x* along *X* axis;

+ or – *y* along *Y* axis;

+ or – *z* along *Z* axis.

4.3 Rotations

Rotations about *X*, *Y*, and *Z* axes are expressed in the following way:

+ or – *A* about *X* axis;

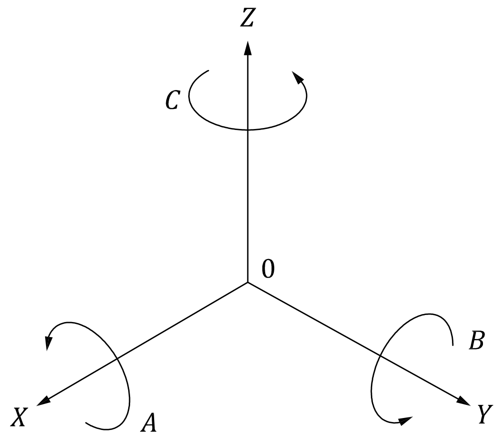
+ or – *B* about *Y* axis;

+ or – *C* about *Z* axis.

A, *B* and *C* are also called roll, pitch and yaw, respectively.

Positive *A*, *B* and *C* are in the directions to advance right-hand screws in the positive *X*, *Y* and *Z* directions, respectively (see Figure 2).

General rotations are expressed by the combination of individual rotations.



Key

A roll

B pitch

C yaw

Figure 2 — Rotations

4.4 Nomenclature for manipulator axes

If the axes are numerically designated, axis 1 shall be the first motion closest to the base mounting surface, axis 2 the second motion, and so on, and axis *m* the motion to which the mechanical interface is attached.

NOTE Examples are given in Annex A.

5 Coordinate systems

5.1 World coordinate system, O_0 - X_0 - Y_0 - Z_0

The origin of the world coordinate system, O_0, shall be defined by the users in accordance with their requirements. The $+Z_0$ axis is collinear but in the opposite direction to the acceleration of gravity vector. The $+X_0$ axis shall be defined by the users in accordance with their requirements (see Figure 3).

5.2 Base coordinate system, O_1 - X_1 - Y_1 - Z_1

The origin of the base coordinate system, O_1, shall be defined by the manufacturer of the robot. The $+Z_1$ axis is in the direction of the mechanical structure of the robot perpendicularly away from the base mounting surface. The $+X_1$ axis points away from the origin and passes through the projection of the centre of the working space, C_w, onto the plane of the base mounting surface (see Figures 3 and 4). When the robot configuration precludes this convention, the direction of the $+X_1$ axis shall be defined by the manufacturer.

NOTE Examples of the base and mechanical interface coordinate systems are given in Annex A.

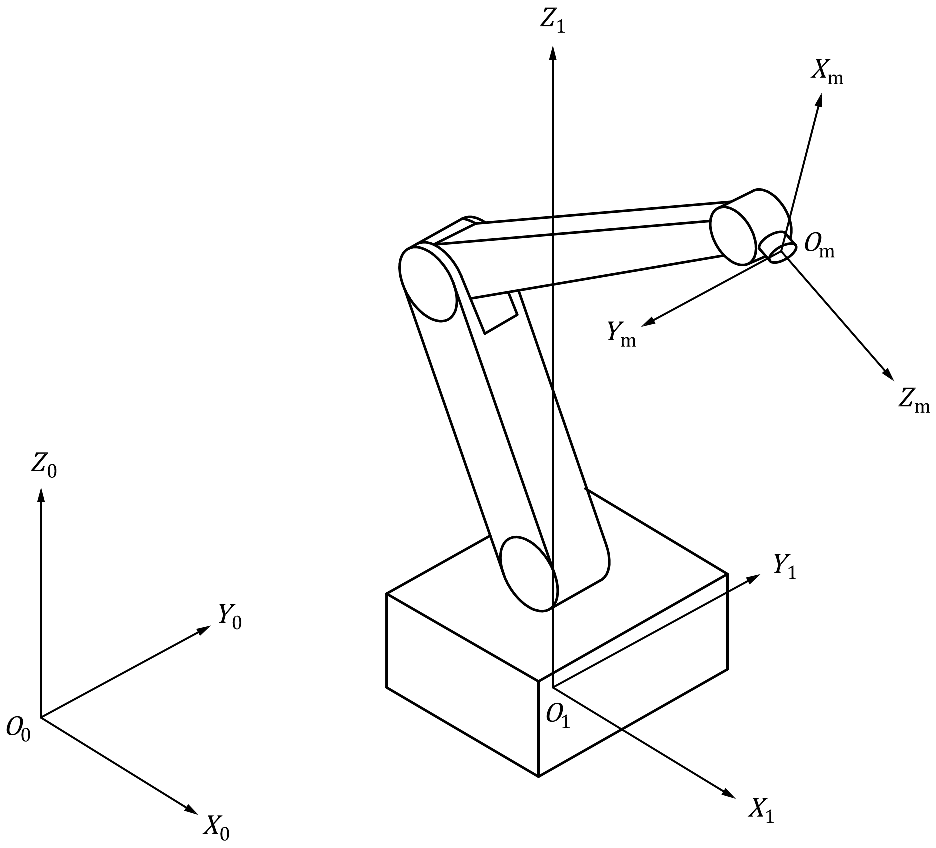


Figure 3 — Examples of coordinate systems

5.3 Mechanical interface coordinate system, O_m - X_m - Y_m - Z_m

The origin of the mechanical interface coordinate system, O_m, is the centre of the mechanical interface. The $+Z_m$ axis points perpendicularly away from the mechanical interface. The $+X_m$ axis is defined as the line parallel to the $+Z_1$ ($+X_1$) axis with the mechanical interface aligned parallel to the plane Y_1 Z_1 (X_1 Y_1) and the robot primary and secondary axes nearest their mid-positions. When the robot configuration precludes this convention, the position of the primary axes shall be defined by the manufacturer (see Figure 3).

NOTE Examples of the base and mechanical interface coordinate systems are given in Annex A.

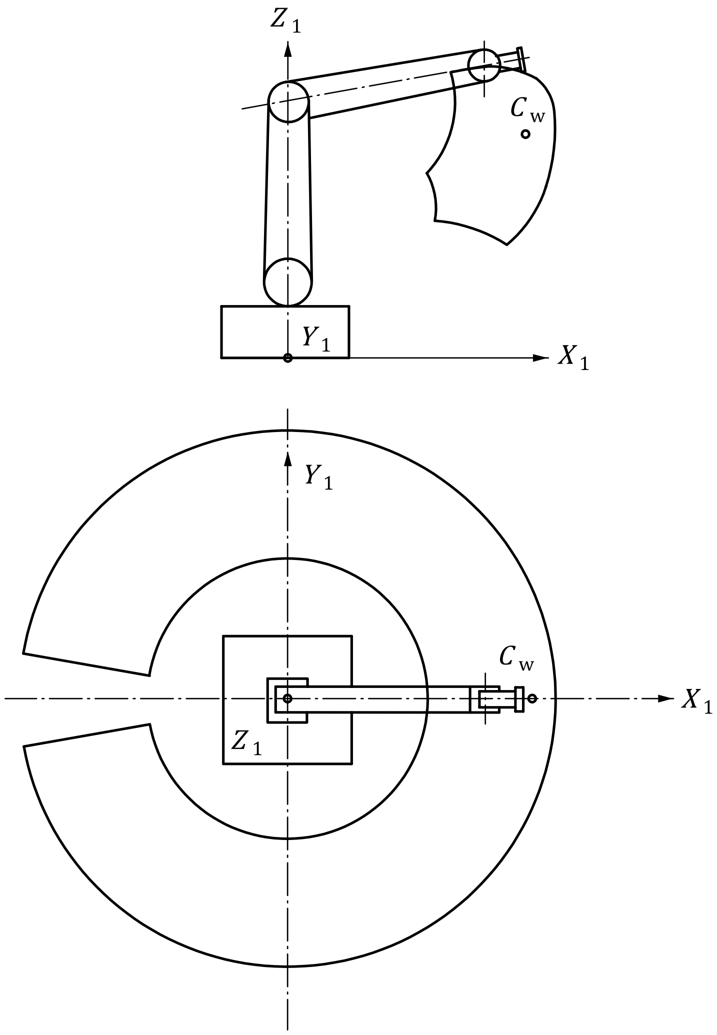


Figure 4 — Examples of robot working space

5.4 Tool coordinate system (TCS), O_t - X_t - Y_t - Z_t

The origin of the tool coordinate system, O_t, is the tool centre point (TCP) (see Figure 5). The +Z_t axis is tool dependent, normally in the direction of the tool. In case of planar grasp-type grippers, the +Y_t axis is on the moving plane of fingers.

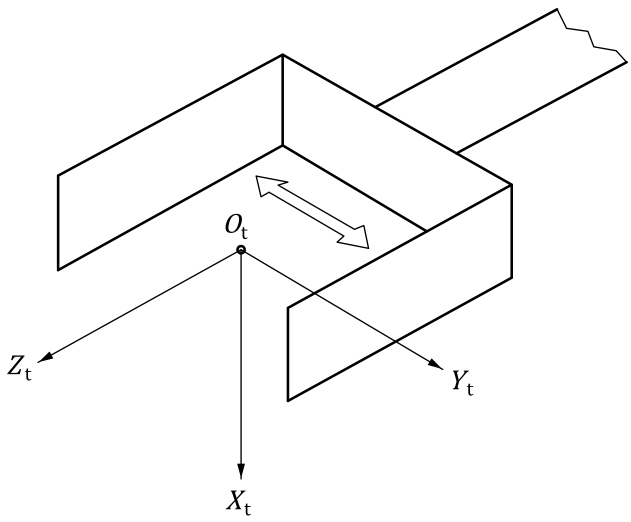


Figure 5 — Example of tool coordinate system

5.5 Mobile platform coordinate system, O_p - X_p - Y_p - Z_p

The origin of the mobile platform coordinate system, O_p, is the mobile platform origin. The $+X_p$ axis is normally taken in the forward direction of the mobile platform. The $+Z_p$ axis is normally taken in the upward direction of the mobile platform (see Figure 6).

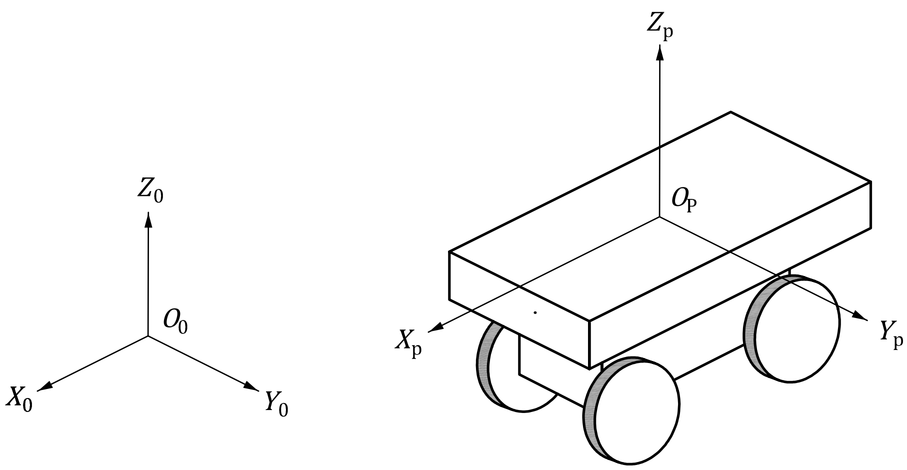
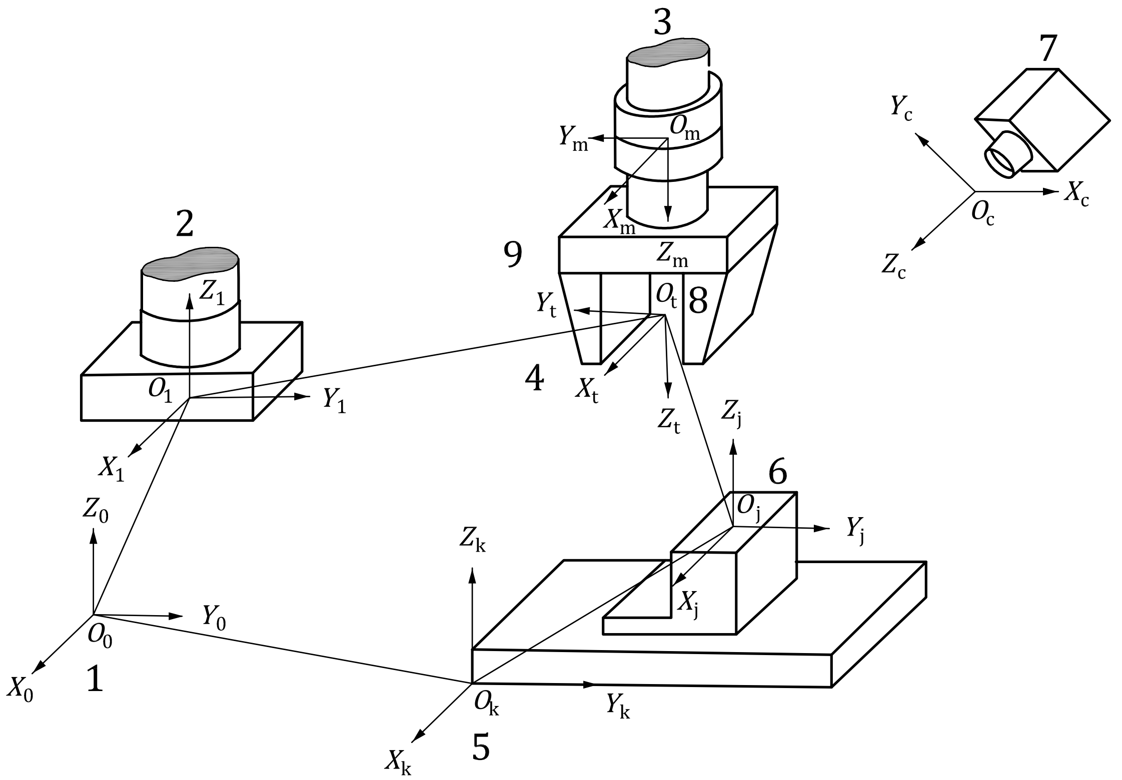


Figure 6 — Example of mobile platform coordinate system

5.6 Task coordinate system, O_k - X_k - Y_k - Z_k

The task coordinate system is illustrated in Figure 7.



Key

1 world coordinate system
2 base coordinate system
3 mechanical interface coordinate system
4 tool coordinate system
5 task coordinate system
6 object coordinate system
7 camera coordinate system
8 TCP
9 gripper

Figure 7 — Coordinate systems in object handling

5.7 Object coordinate system, O_j - X_j - Y_j - Z_j

The object coordinate system is illustrated in Figure 7.

5.8 Camera coordinate system, O_c - X_c - Y_c - Z_c

The camera coordinate system is illustrated in Figure 7.

Annex A
(informative)

Examples of coordinate systems for different mechanical structures

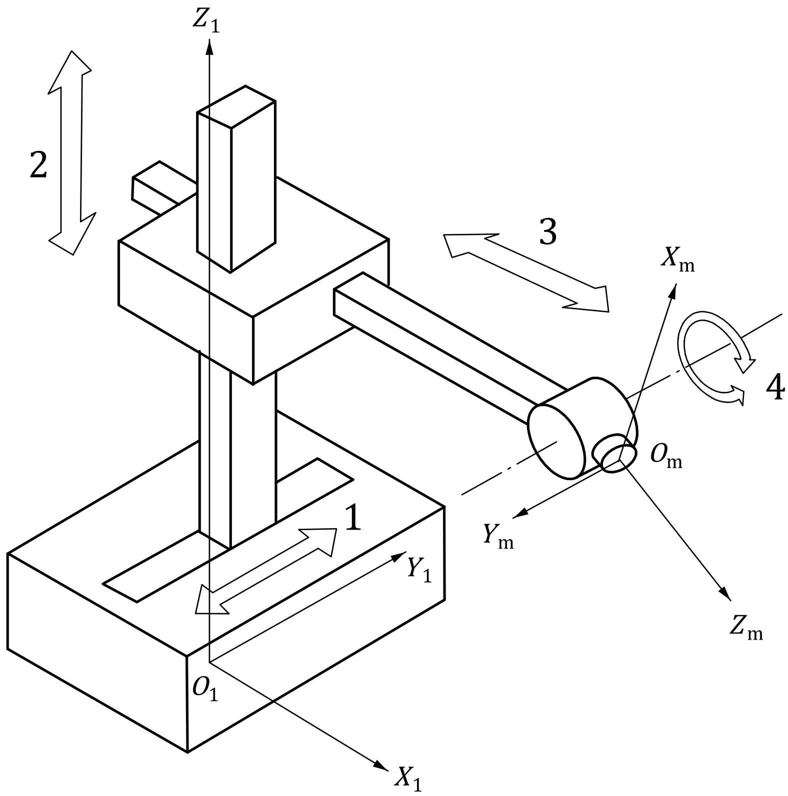


Figure A.1 — Rectangular robot

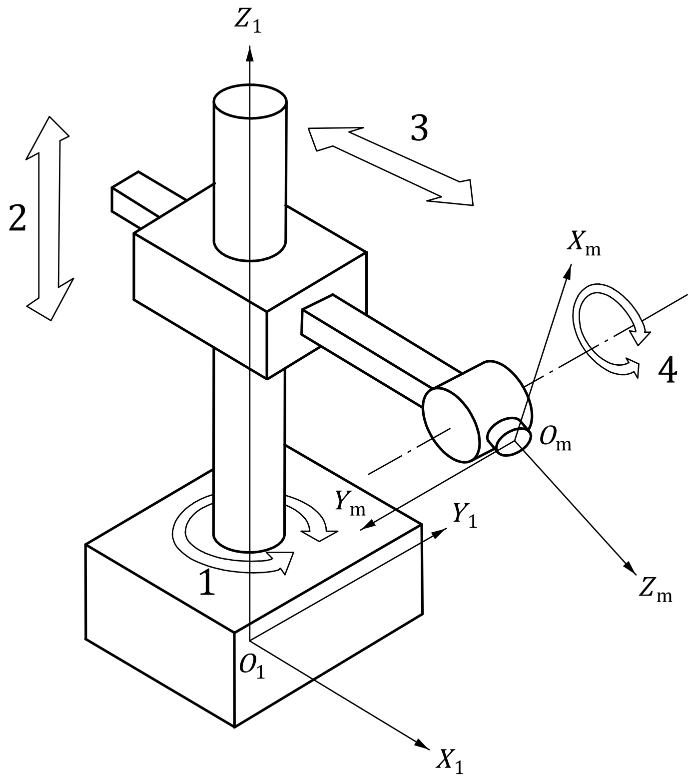


Figure A.2 — Cylindrical robot

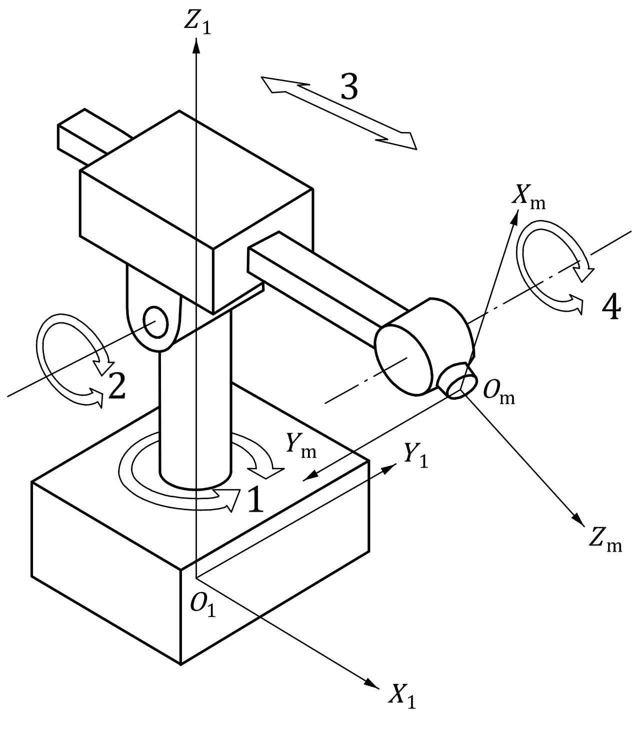


Figure A.3 — Polar robot

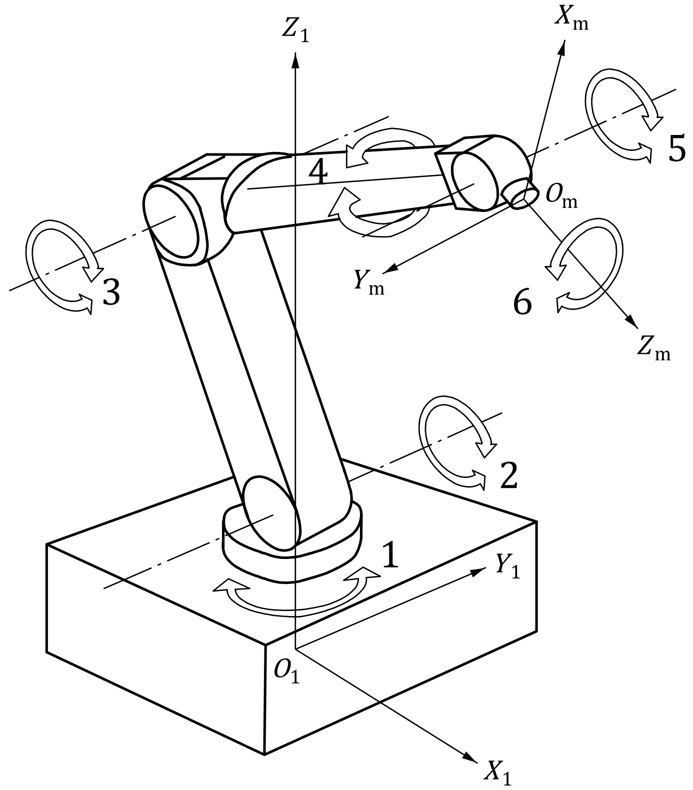


Figure A.4 — Articulated robot

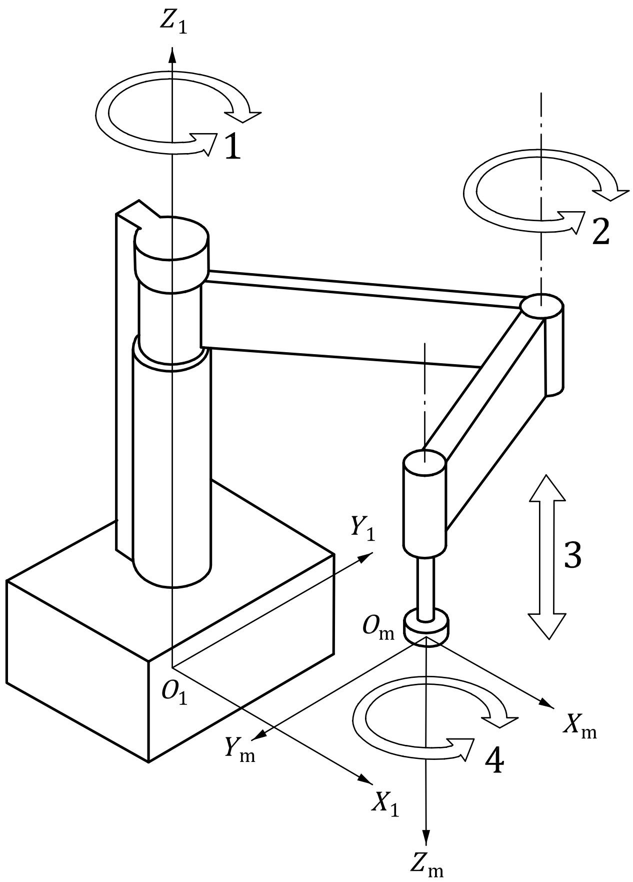


Figure A.5 — SCARA robot

Bibliography

[1] ISO 9283:1998, *Manipulating industrial robots — Performance criteria and related test methods*

[2] ISO 9946:1999, *Manipulating industrial robots — Presentation of characteristics*

[3] ISO 14539:2000, *Manipulating industrial robots — Object handling with grasp-type grippers — Vocabulary and presentation of characteristics*

ICS 25.040.30
Price based on 12 pages