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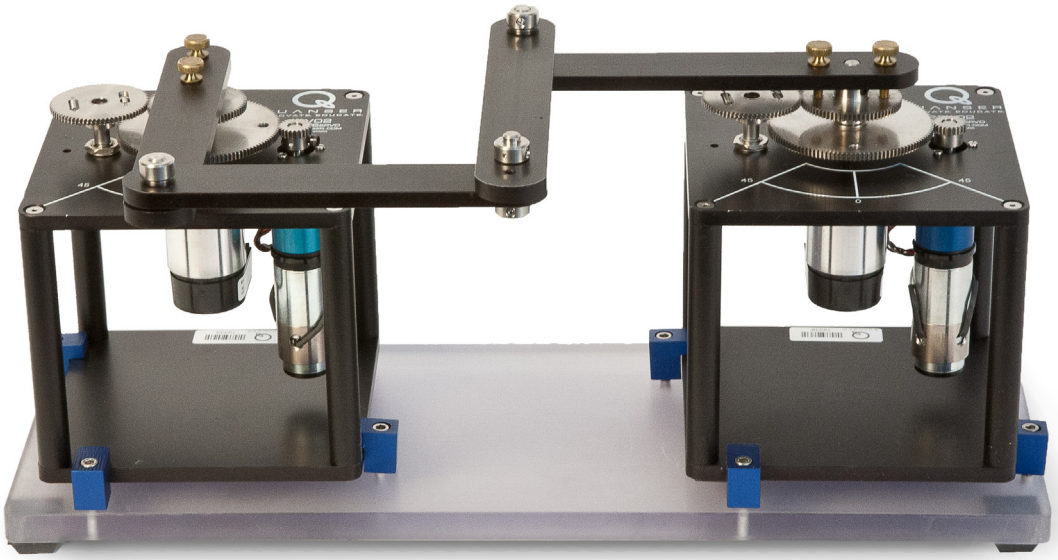
USER MANUAL

2 DOF Robot Experiment

Set Up and Configuration



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Quanser Inc.
119 Spy Court
Markham, Ontario
L3R 5H6
Canada
info@quanser.com
Phone: 1-905-940-3575
Fax: 1-905-940-3576

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- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

CONTENTS

1 PRESENTATION

1.1 Description

The Quanser 2 DOF Robot system, pictured in Figure 1.1, is a 2-DOF "pantograph" type robot. The goal, typically, is to manipulate the X-Y position of a 4-bar linkage end effector. The system is planar and has 2 actuated and 3 unactuated revolute joints. Two servo motors mounted at a fixed distance control two arms coupled via two non-powered two-link arms. Such a system is similar to the kinematic problems encountered in the control of larger 6-DOF robots including singularities.

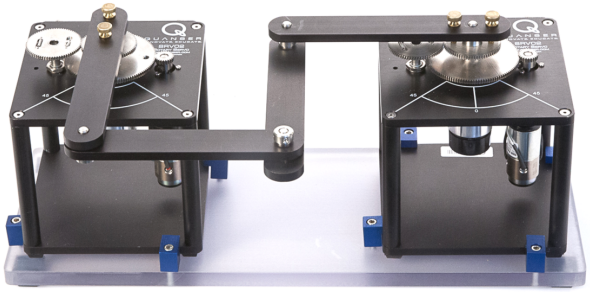

Figure 1.1: 2 DOF Robot System

Caution: This equipment is designed to be used for educational and research purposes and is not intended for use by the general public. The user is responsible to ensure that the equipment will be used by technically qualified personnel only.

1.2 Experiment Overview

As described in Table 1.1, below, the 2 DOF Robot module by itself is supplied with two position control experiments. However when combined with the 2 DOF Joint, additional experiments can be performed such as 2 DOF Gantry and 2 DOF Inverted Pendulum.

Experiment Name	Module Option Needed	Description
Joint Space Control	2 DOF Robot	Design a joint-level position controller for each servo using a PID-type compensator.
Work Space Control	2 DOF Robot	Design a task-space position controller that controls the position of the end-effector to a desired point in the Cartesian X-Y plane.

Table 1.1: Possible experiments with the 2 DOF Robot and 2 DOF Joint modules.

2 COMPONENTS

The components of the 2 DOF Robot system are listed in Table 2.1 and labeled in Figure 2.1, below

ID	Component	ID	Component
1	Four-bar linkage	5	Support base plate
2	Robot end-effector	6	Servo clamp
3	SRV02 A	7	Linkage thumbscrews
4	SRV02 B		

Table 2.1: 2 DOF Robot components.

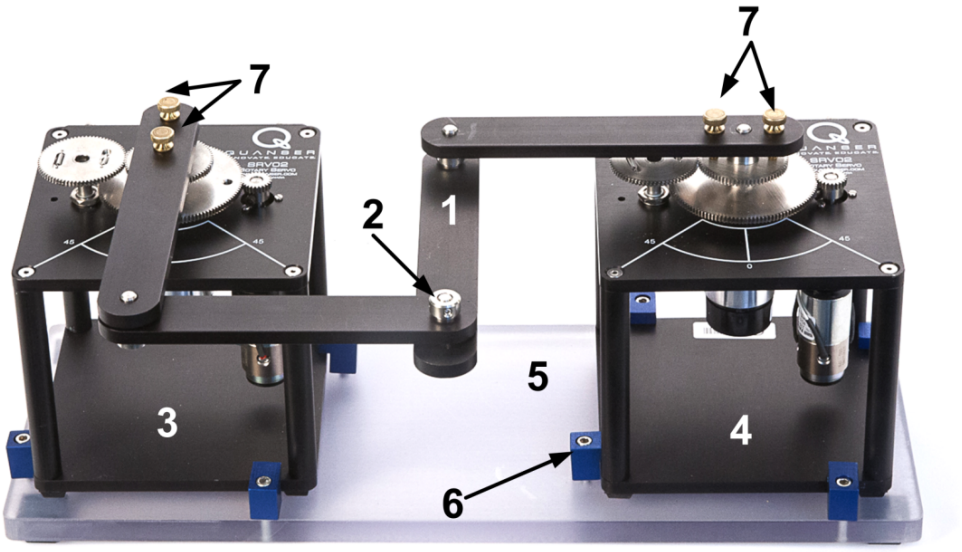

Figure 2.1: 2 DOF Robot System

3 SPECIFICATIONS

Table 3.1, lists and characterizes the main parameters associated with the SRV02 2 DOF Robot module. Some of these parameters are used in the mathematical model.

Symbol	Description	Value	Unit
M_{lk}	Mass of four-bar linkages	0.335	kg
M_b	Mass of single link	0.065	kg
L_b	Length of link	0.127	m
$J_{b,og}$	Link moment of inertia about cog.	8.74×10^{-05}	kg-m^2
$J_{b,piv}$	Link moment of inertia about pivot.	4.41×10^{-04}	kg-m^2
$J_{eq,linkage}$	Equivalent moment of inertia of 4-bar linkage.	1.49×10^{-3}	kg-m^2
J_{eq}	Equivalent moment of inertia of 4-bar linkage including motor inertia.	3.59×10^{-3}	kg-m^2
	2 DOF Robot Overall Dimensions	40 x 30 x 20	cm
	2 DOF Robot Total Mass	4.0	kg

Table 3.1: 2 DOF Robot system specifications.

4 SYSTEM SETUP

Caution: If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Follow this procedure to setup the Quanser 2 DOF Robot module for experimental use:

1. Place the two Rotary Servo Motor (SRV02) systems onto the support plate, ID #5 in Figure 2.1, above, and as shown in Figure 4.1a.

   Note: Ensure the Rotary Servo Base Unit is setup in the high gear configuration.

2. The support plate has a total of 8x clamps. Tighten the screws of the 4x clamps on each servo until the SRV02 is properly fastened to the base. You do not need to overly tighten the clamps. See Figure 4.1b.

3. Mount the four-bar linkage on the load output shafts of both SRV02 systems, as shown in Figure 4.1c. Make sure the long side of the arm can be lined up the 0 degree marked on the SRV02.

4. Tighten both thumbscrews, ID #7 in Figure 2.1, to fasten the links onto the load shaft of the servo units.

5. Before running any experiments, it is recommended that the base support plate be clamped down onto an edge of a table. This prevents the chance of it falling over.

(a) SR02 on Mounting Plates

(b) Tighten clamps

(c) Mounting four-linkage bar

Figure 4.1: 2 DOF Robot System Setup

5 WIRING PROCEDURE

The following is a listing of the hardware components used in this experiment:

1. **Power Amplifier:** Quanser VoltPAQ-X2, 2x VoltPAQ-X1, or equivalent.
2. **Data Acquisition Device:** Q1-cRIO, Q2-USB, Q8-USB, QPID/QPIDe. NI DAQ Device, or equivalent.
3. **Rotary Servo Plant:** Quanser SRV02-ET.
4. **Four-bar linkage module:** Quanser 2 DOF Robot module.

See the references listed in Section 8 for more information on these components. The required cables are described in Section 5.1 and the procedure to connect the above components is given in Section 5.2.

Caution: When Using the Quanser VoltPAQ power amplifier, **make sure set the Gain to 1!**

5.1 Cable Nomenclature

Table 5.1, below, provides a description of the standard cables used in the wiring of the SRV02 and 2 DOF Robot system.

Cable	Type	Description
 (a) RCA Cable	2xRCA to 2xRCA	This cable connects an analog output of the data acquisition (DAQ) device to the power module for proper power amplification.
 (b) Motor Cable	4-pin-DIN to 6-pin-DIN	This cable connects the output of the power module, after amplification, to the desired DC motor on the servo.
 (c) Encoder Cable	5-pin-stereo-DIN to 5-pin-stereo-DIN	This cable carries the encoder signals between an encoder connector and the data acquisition (DAQ) device (to the encoder counter). Namely, these signals are: +5 VDC power supply, ground, channel A, and channel B

Table 5.1: Cables used to connect SRV02 to amplifier and DAQ device

5.2 Typical Connections

This section describes the typical connections used for to connect the SRV02 and 2 DOF Robot system to a data acquisition (DAQ) device and a two-channel amplifier. The connections are given in Table 5.2 and illustrated in Figure 5.3 and Figure 5.2. The detailed wiring procedure is given below.

Cable #	From	To	Signal
1	Data acquisition (DAQ) device:Analog Output #0	Amplifier Command #0 connector	Control signal to the amplifier driving SRV02 A.
2	Data acquisition (DAQ) device:Analog Output #1	Amplifier Command #1 connector	Control signal to the amplifier driving SRV02 B.
3	Amplifier 0 "To Load" connector	SRV02 A "Motor" connector	Power leads to the DC motor of SRV02 A.
4	Amplifier 1 "To Load" connector	SRV02 B "Motor" connector	Power leads to the DC motor of SRV02 B.
5	Data acquisition (DAQ) device:Encoder Input #0	SRV02 A "Encoder" connector	SRV02 A encoder load shaft angle measurement.
6	Data acquisition (DAQ) device:Encoder Input #1	SRV02 B "Encoder" connector	SRV02 B encoder load shaft angle measurement.
7	Emergency Stop Switch	E-Stop connector on VoltPAQ	The amplifier is deactivated when the E-Stop switch is pressed down

Table 5.2: Quanser 2 DOF Robot system wiring summary.

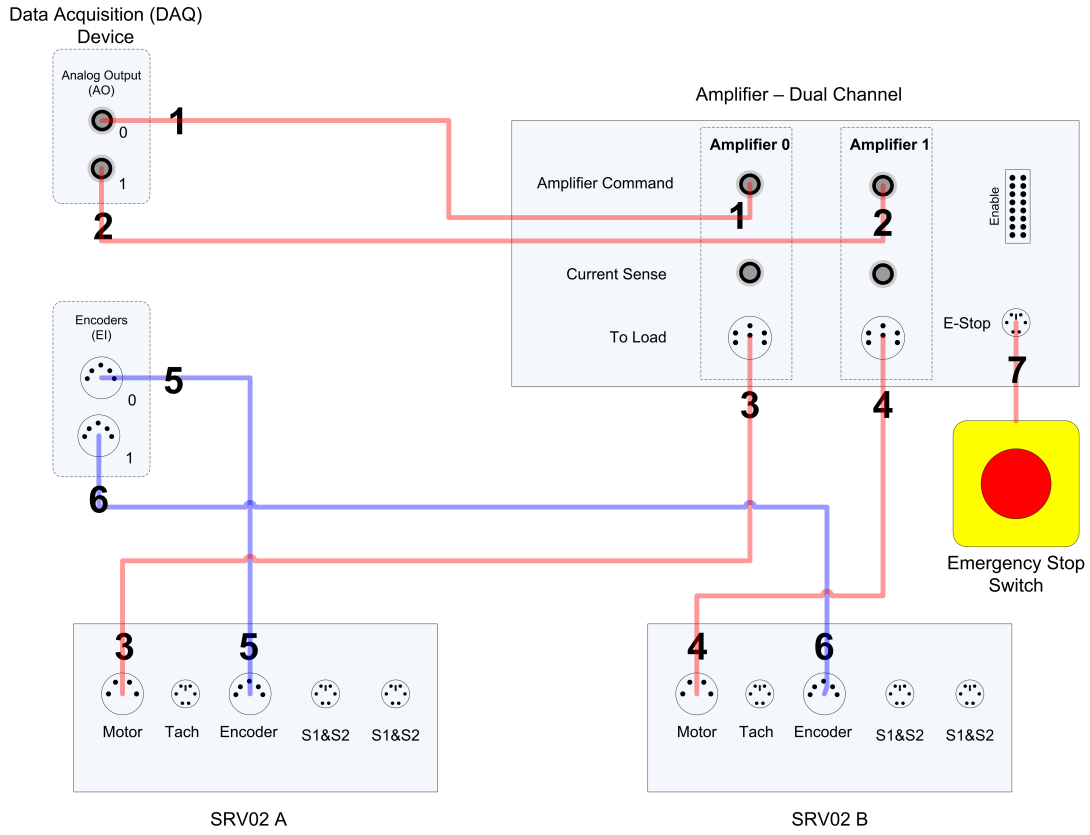

Figure 5.1: 2D Robot connection diagram

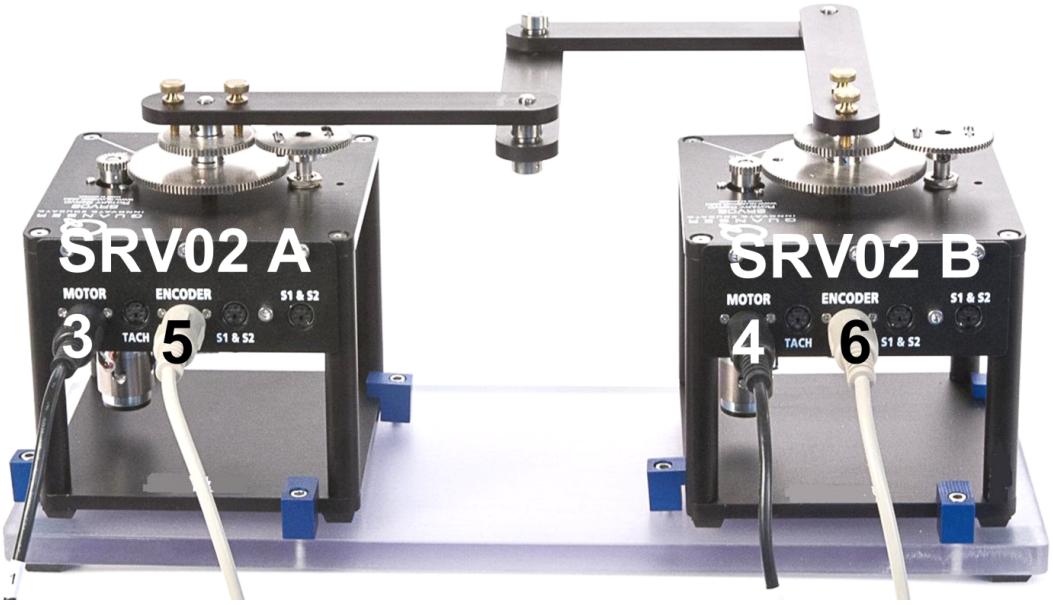

Figure 5.2: Connections on 2 DOF Robot plant.

The following steps describes a detailed wiring procedure of the 2 DOF Robot to the SRV02, data-acquisition board and a dual channel power amplifier

1. It is assumed that the data acquisition (DAQ) device is already installed as discussed in its respective User Manual.
2. Make sure everything is powered off before making any of these connections. This includes turning off your PC and the amplifiers.
3. Connect one end of the 2xRCA to 2xRCA cable from the Analog Output Channel #0 on the data acquisition (DAQ) device to the Amplifier Command 0 connector on the amplifier, that will be connected to SRV02 A (e.g. red RCA connectors). See cable #1 shown in Figure 5.3. This carries the attenuated SRV02 A motor voltage control signal, $V_{m,a}/K_{a,a}$, where $K_{a,a}$ is the amplifier A gain.
4. Connect the one end of the 2xRCA to 2xRCA cable from the Analog Output Channel #1 on the data acquisition (DAQ) device to the Amplifier Command 1 connector on the amplifier, that will be connected to SRV02 B (e.g. white RCA connectors). See cable #2 shown in Figure 5.3. This carries the attenuated SRV02 B motor voltage control signal, $V_{m,b}/K_{a,b}$, where $K_{a,b}$ is the amplifier B gain.
5. Connect the 4-pin-stereo-DIN to 6-pin-stereo-DIN from To Load 0 on the amplifier to the Motor connector on the SRV02. See connection #3 shown in Figure 5.3 and Figure 5.2. The cable transmits the amplified voltage that is applied to the SRV02 A motor and is denoted $V_{m,a}$.
6. Connect the 4-pin-stereo-DIN to 6-pin-stereo-DIN from To Load 1 on the amplifier to the Motor connector on the SRV02. See connection #4 shown in Figure 5.3 and Figure 5.2. The cable transmits the amplified voltage that is applied to the SRV02 B motor and is denoted $V_{m,b}$.
7. Connect the 5-pin-stereo-DIN to 5-pin-stereo-DIN cable from the Encoder connector on the SRV02 A panel to Encoder Input # 0 on the data acquisition (DAQ) device, as depicted by connection #5 in Figure 5.3 and Figure 5.2. This carries the SRV02 A load shaft angle measurement and is denoted by the variable $\theta_{l,a}$.

   Caution: Any encoder should be directly connected to the Quanser data acquisition (DAQ) device (or equivalent) using a standard 5-pin DIN cable. DO NOT connect the encoder cable to the amplifier!
8. Connect the 5-pin-stereo-DIN to 5-pin-stereo-DIN cable from the Encoder connector on the SRV02 B panel to Encoder Input # 1 on the data acquisition (DAQ) device, as depicted by connection #6 in Figure 5.3 and Figure 5.2. This carries the SRV02 B load shaft angle measurement and is denoted by the variable $\theta_{l,b}$.

9. Connect the Emergency Stop Switch to the E-Stop connector on the VoltPAQ. This enable or disable the command output on the amplifier.

5.2.1 Connections using a two Single Channel Amplifiers

Alternatively, this section shows the typical wiring of the 2 DOF robot when using 2x single channel power amplifier.

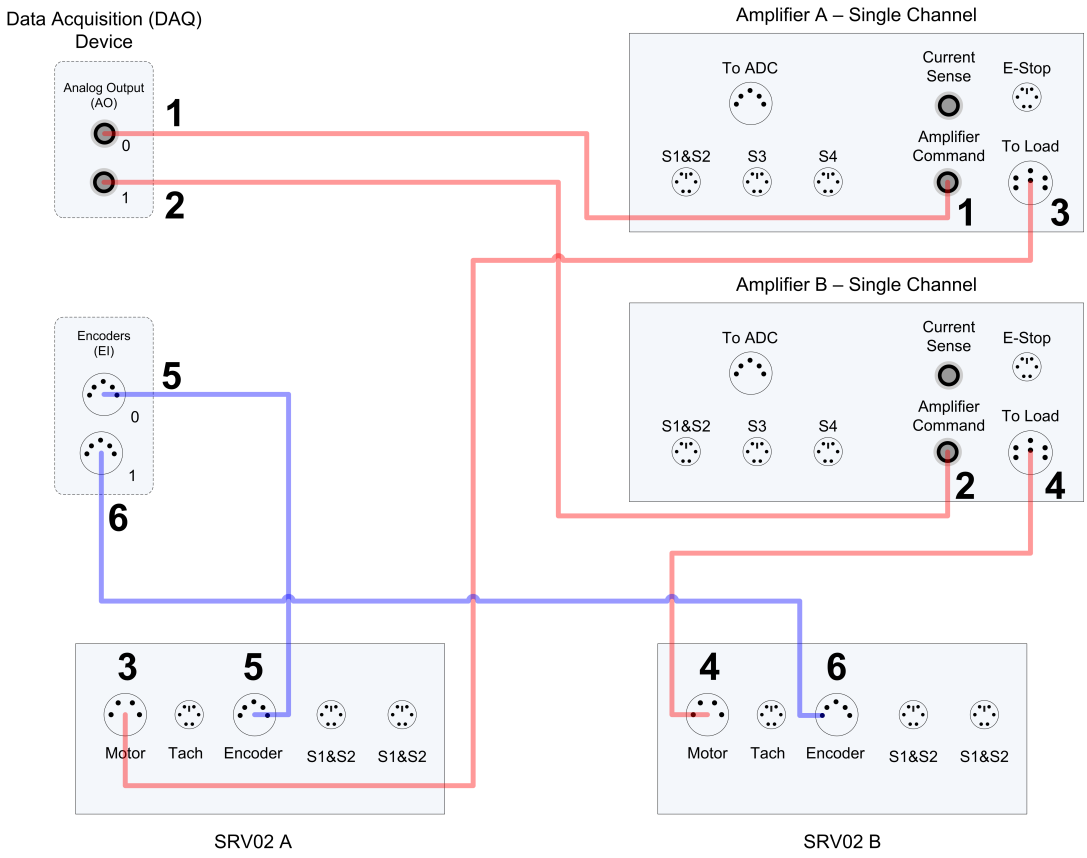

Figure 5.3: 2 DOF Robot connection diagram using two single channel amplifiers

Caution: When Using the Quanser VoltPAQ power amplifier, **make sure set the Gain to 1!**

6 TROUBLESHOOTING

The actuators and sensors of the 2 DOF Robot plant are all on the SRV02 units themselves. Therefore, see Reference [1] for any information regarding the testing and troubleshooting of the SRV02 devices.

7 TECHNICAL SUPPORT

To obtain support from Quanser, go to http://www.quanser.com/ and click on the Tech Support link. Fill in the form with all the requested software and hardware information as well as a description of the problem encountered. Also, make sure your e-mail address and telephone number are included. Submit the form and a technical support person will contact you.

REFERENCES

[1] Quanser Inc. *SRV02 User Manual*, 2012.

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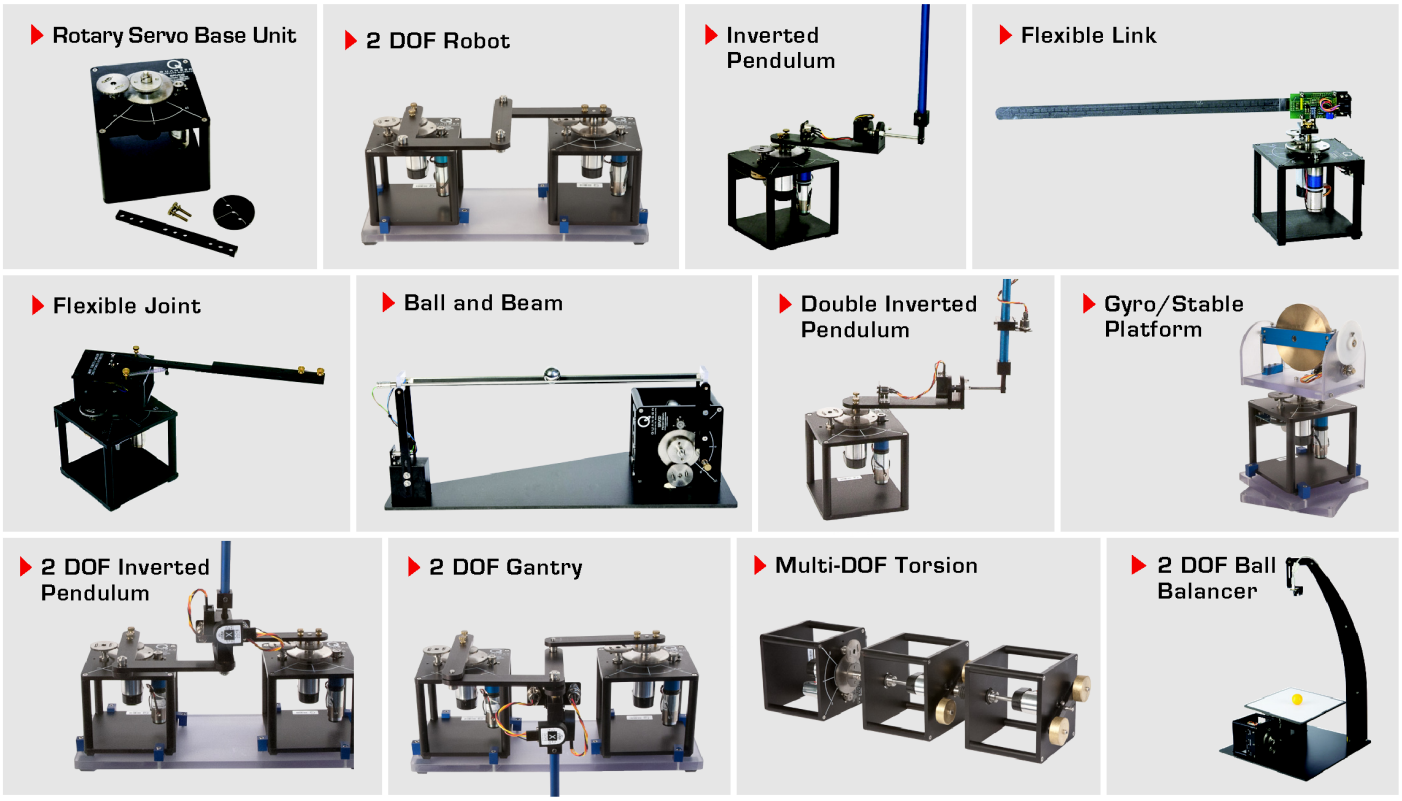

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