QUANSER
INNOVATE · EDUCATE

MAGNETIC LEVITATION

The Magnetic Levitation system is a classic electro-mechanical experiment with interesting nonlinear dynamics and control challenges.

GIVE STUDENTS CONTROL OF A REAL-WORLD APPLICATION

Magnetic levitation technology is used in systems such as Maglev trains and electromagnetic cranes. Research is also being done to use magnetic control technology for contactless, high-precision positioning of wafers in photolithography.

HOW IT WORKS

The Quanser Magnetic Levitation (MAGLEV) device is a single degree of freedom electromagnet-based system that allows users to levitate a ball vertically up and down. The overhead electromagnet, wound in red coil, generates an attractive force on the metal ball that initially sits on the post. The total air gap or travel distance between the ball and the magnet (when its initially on the post) is 14 mm. The position of the ball is measured using a photo-sensitive sensor embedded inside the post. The system also includes a current sensor to measure the current inside the electromagnet's coil.

The force between electromagnet and ball is highly nonlinear. Further, the electromagnet itself has its own dynamics that must be compensated for. The challenging dynamics of the system make it perfect for teaching modeling, linearization, current control, position control, and using multiple loops (i.e. cascade control). It could also be used to test and implement more advanced control strategies, such as mutli-variable, gain scheduling, and nonlinear control*.

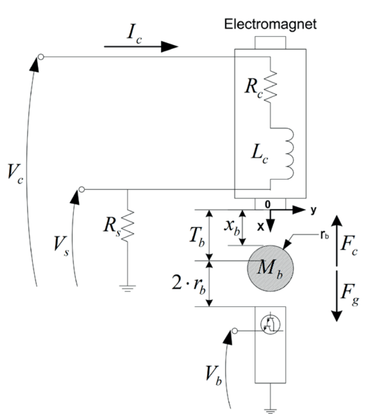


Figure 1.
Diagram illustrates dynamics of the Magnetic Levitation system.

System specifications on reverse page.

MAGNETIC LEVITATION WORKSTATION COMPONENTS

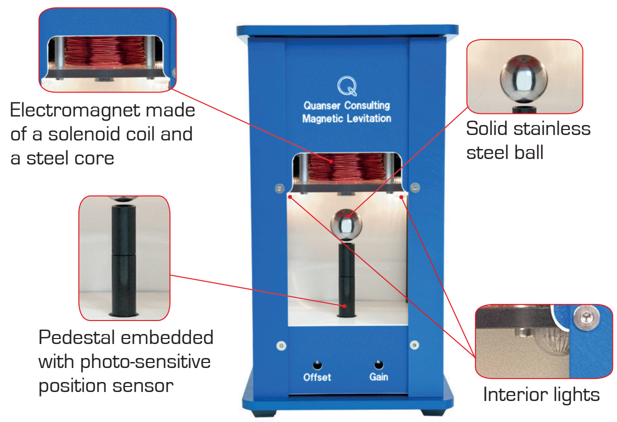
- Magnatic Levitation plant
- Q2-USB data acquisition device
- VoltPAQ-X1 linear voltage amplifier
- QUARC real-time control software for MATLAB®/Simulink®
- Instructor and Student Workbooks, User Manual, and Quick Start Guide (provided in digital format)
- Sample of pre-built controllers and complete dynamic model

Magnetic Levitation workstation

* not supplied with system.

SYSTEM SPECIFICATIONS

Magnetic Levitation



CURRICULUM TOPICS PROVIDED

- Derivation of dynamic model from first-principles
- Transfer function representation
- Linearization
- Current control
- Position control
- PID
- Feed-forward
- Control parameter tuning

FEATURES

- One degree of freedom (1 DOF) - ball levitates vertically up and down
- Electromagnet made up of a solenoid coil and steel core
- Photo-sensitive ball position sensor
- Ball position sensor can be calibrated (using gain and offset knobs) according to lighting conditions
- Analog coil current sensor
- Easy-connect cable and connectors
- Fully compatible with MATLAB®/Simulink® and LabVIEW™
- Fully documented system model and parameters provided for MATLAB®/Simulink®, LabVIEW™ and Maple™
- Open architecture design, allows users to design their own controller

DEVICE SPECIFICATIONS

Device mass	3.8 kg
Dimensions – H × W × L	15.1 cm × 15.1 cm × 27.6 cm
Ball position sensor sensitivity	0.28 cm/V
Coil inductance	412.5 mH
Coil resistance	10 Ω
Number of turns in the coil wire (approximate)	2450
Coil length	8.25 cm
Coil steel core radius	0.8 cm
Electromagnet force constant	6.53×10^{-5} N.m^2/A^2
Current sense resistance	1 Ω
Steel ball radius	1.27 cm
Steel ball mass	0.068 kg
Steel ball travel	1.4 cm
Magnetic permeability constant	$4\pi \times 10^{-7}$ H/m

COMPLETE WORKSTATION COMPONENTS

Plant	Magnetic Levitation
Control design environment	Quanser QUARC® add-on for MATLAB®/Simulink® Quanser Rapid Control Prototyping (RCP) Toolkit® add-on for NI LabVIEW™
Documentation	Quick Start Guide, User Manual and Instructor and Student Workbooks
Real-time targets	Microsoft Windows® and NI CompactRIO
Data acquisition devices	Quanser Q2-USB, Q8-USB, QPID/QPIDe, or NI CompactRIO with two Quanser Q1-cRIO modules
Amplifier	Quanser VoltPAQ-X1 linear voltage amplifier

The linear state space model and a sample controller(s) are supplied

About Quanser:
Quanser is the world leader in education and research for real-time control design and implementation. We specialize in outfitting engineering control laboratories to help universities captivate the brightest minds, motivate them to success and produce graduates with industry-relevant skills. Universities worldwide implement Quanser's open architecture control solutions, industry-relevant curriculum and cutting-edge work stations to teach Introductory, Intermediate or Advanced controls to students in Electrical, Mechanical, Mechatronics, Robotics, Aerospace, Civil, and various other engineering disciplines.

made|for|science
made-for-science.com | quanser@made-for-science.com | +49 69 2474906 10