HIGH FIDELITY LINEAR CART SYSTEM

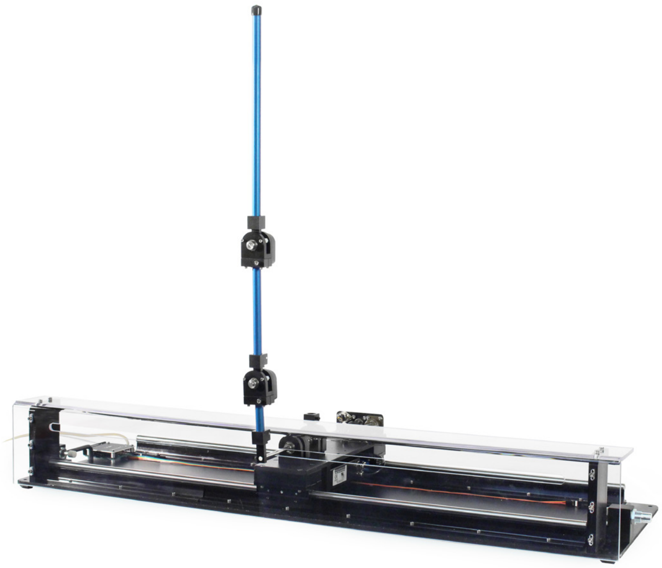
QUANSER
INNOVATE. EDUCATE.

The High Fidelity Linear Cart system is a precise and robust platform for study of basic and advanced servomotor control concepts, adding additional challenges with an array of single, double, dual and triple inverted pendulums.

FROM SINGLE TO TRIPLE INVERTED PENDULUM

The High Fidelity Linear Cart (HFLC) system is ideally suited to introduce advanced control concepts and theories relevant to real world applications of servomotors, taking the classic inverted pendulum challenge to the next level with an array of experiments including double, dual and triple inverted pendulums. Students learn how to design and implement a state-feedback control system to track the cart position while minimizing the swing of the pendulum.

In addition to five different pendulums (three single pendulums of different length, one double pendulum and one triple pendulum), an optional Linear Flexible Joint can be connected to the HFLC to create experiments of increased complexity. Students learn how to design a state feedback control system that regulates the position of the cart and the Linear Flexible Joint cart to a desired setpoint while dampening the spring.



System specifications on reverse page.

HOW IT WORKS

The HFLC system consists of a precisely machined solid aluminum cart driven by a high-power 3-phase brushless DC motor. The cart slides along two high precision, ground hardened steel guide rails with self-aligning linear bearings for true linear motion. The motor shaft has a pinion gear that rides on a track permitting the cart to move in a linear fashion. Both rack and pinion are made of hardened steel and mesh with a tight tolerance. The rack-and-pinion mechanism eliminates undesirable effects found in belt-driven and free wheel systems, such as slippage or belt stretching, ensuring consistent and continuous traction.

The complete assembly rests on a solid aluminum base to ensure straightness, increased rigidity and support. With this design, the linear positioning system can obtain high speed, high acceleration and repeatability.

The cart is also equipped with two unactuated rotary joints with ball bearings to attach free-turning pendulum rods. The rods can be controlled individually or in combination to perform a variety of experiments with increasing complexity. One pendulum can be mounted directly on the cart, the rotation of the cart joint is mechanically limited to ± 30.9 degrees around its "inverted" vertical posture. The second pendulum can be suspended in front of the cart through an extended pivot shaft and can be used to perform self-erecting and gantry experiments.

The motor shaft is coupled to a high-resolution optical encoder that accurately measures the position of the cart. The angles of both pendulums are also measured by the optical encoders, allowing for multiple turns and continuous measurement over the entire range of motion.

HFLC WORKSTATION COMPONENTS

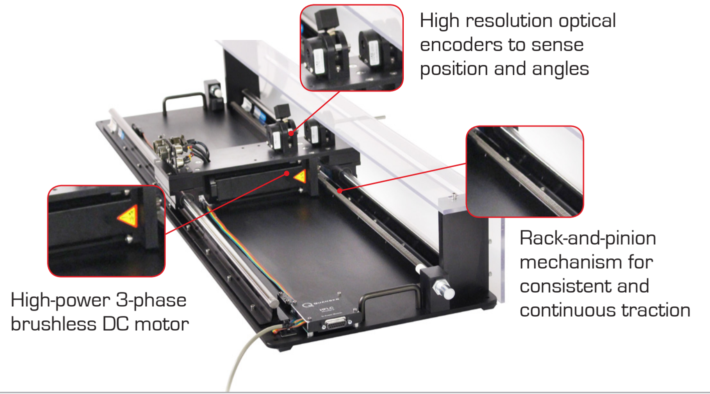
High Fidelity Linear Cart with five different pendulums
Linear Flexible Joint (optional, can be purchased separately)
Q8 data acquisition device
UPM 180-25B amplifier
QUARC real-time control software for MATLAB®/Simulink®
Laboratory Guide and User Manual (provided in digital format)
Sample pre-built controllers and complete dynamic model

Multiple Experimental Combinations

The HFLC system comes with five different pendulums: three single pendulum rods of different length, one double and one triple pendulum. More experimental combinations can be created by adding an unactuated cart connected to the actuated High Fidelity Linear cart with a single linear flexible joint.

SYSTEM SPECIFICATIONS

High Fidelity Linear Cart System



CURRICULUM TOPICS PROVIDED

- Derivation of dynamic model from first-principles
- Derivation of dynamic model using Lagrange
- Transfer function representation
- State-space representation
- Model validation
- PID control
- State-feedback / LQR control
- Vibration control (for Linear Flexible Joint module)
- Swing-up / balance control

FEATURES

- Precisely machined solid aluminum cart
- High-power 3-phase brushless DC motor
- Rack-and-pinion mechanism for consistent and continuous traction
- Five different pendulums provided with the system: three single pendulums of different length, one double and one triple pendulum
- Optional Linear Flexible Joint module (can be purchased separately)
- High resolution optical encoders to sense position and angles
- Easy-connect cable and connectors
- Fully compatible with MATLAB®/Simulink®
- Fully documented system model and parameters provided for MATLAB®/Simulink® and Maple™
- Open architecture design, allows users to design their own controller

DEVICE SPECIFICATIONS

Rack dimensions (L x W x H)	1.1 m x 0.31 m x 0.18 m
Cart system mass	3.22 kg
Motor current-torque constant	0.36 N.m/A
Motor armature resistance	2.94 W
Motor peak torque	4.82 N.m
Motor peak current	15.6 A
Motor maximum mechanical speed	838 rad/s
Rotor moment of inertia	2.7×10^{-5} kg.m^2
Motor pinion radius	1.11×10^{-3} m
Cart encoder linear position sensitivity	8.523×10^{-6} m/count
Cart encoder resolution (in quadrature)	8192 counts/rev
Pendulum encoder resolution (in quadrature)	4096 counts/rev
Rear pendulum mechanical range	± 30.9 deg

COMPLETE WORKSTATION COMPONENTS

Plant	High Fidelity Linear Cart
Control design environment	Quanser QUARC® add-on for MATLAB®/Simulink®
Documentation	User Manual and Laboratory Guide
Real-time targets	Microsoft Windows®
Data acquisition devices	Quanser Q8
Amplifier	Quanser UPM-180-25B power 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.

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