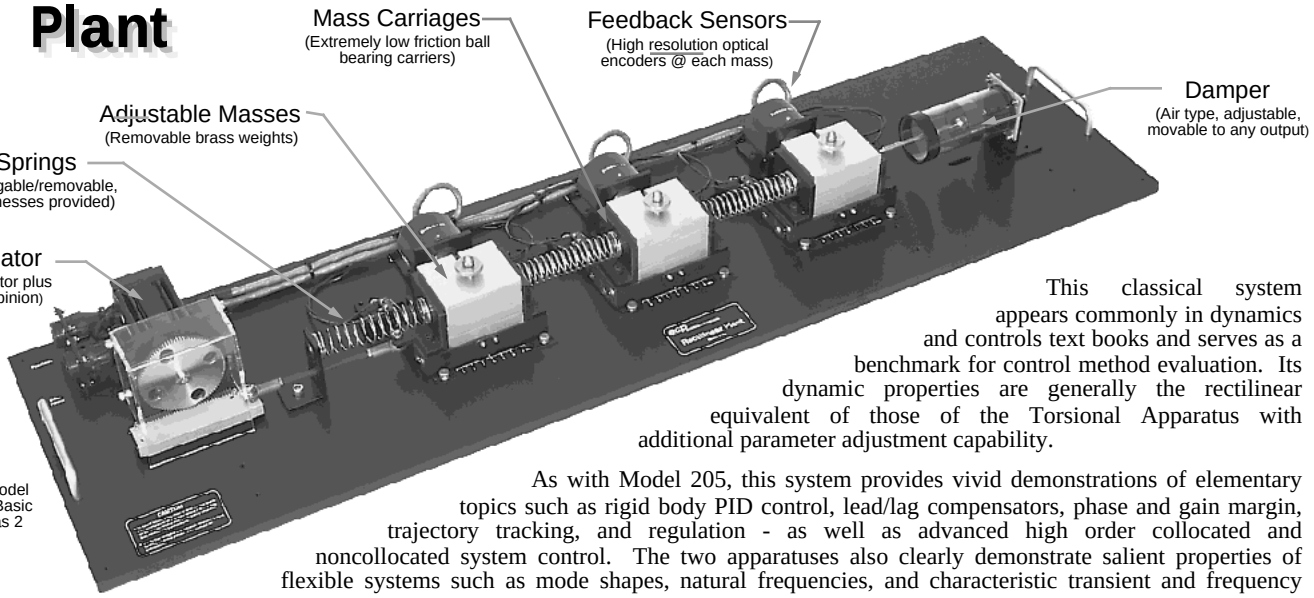
Model 210
Rectilinear Plant



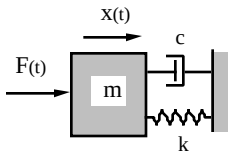
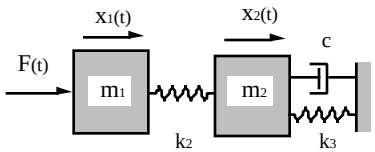
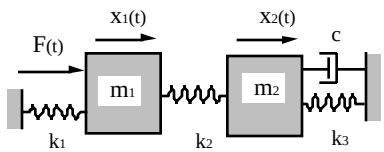
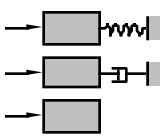
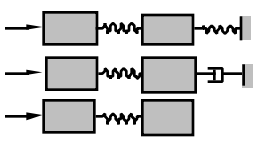
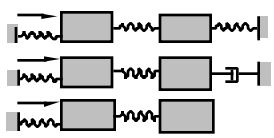
Three mass Model 210a shown. Basic Model 210 has 2 masses

This classical system appears commonly in dynamics and controls text books and serves as a benchmark for control method evaluation. Its dynamic properties are generally the rectilinear equivalent of those of the Torsional Apparatus with additional parameter adjustment capability.

As with Model 205, this system provides vivid demonstrations of elementary topics such as rigid body PID control, lead/lag compensators, phase and gain margin, trajectory tracking, and regulation - as well as advanced high order collocated and noncollocated system control. The two apparatuses also clearly demonstrate salient properties of flexible systems such as mode shapes, natural frequencies, and characteristic transient and frequency responses. An optional secondary drive may be positioned at any output (mass carriage) to create a MIMO plant (requires Executive USR™ software) and provide for the study of disturbance rejection.

Configurations: 12 std, 16 with opt. 3rd mass, 18 with second drive accessory	Damping Adjustment Ratio: >10:1
Dynamics: 2nd, 4th, and 6th (3 mass option) order, Systems types 0, 1, and 2	Feedback: High resolution encoder (160 count/mm)
I/O: SISO, SIMO, MIMO (with sec. drive accessory)	High torque brushless servo motor, precision rack & pinion , 8 N output
Poles and Zeros: Adjustable 1.5-7 Hz	Bench-top size: 31x66x15 cm. (12x26x6 in.)
Mass Adjustment Ratio: 5:1	Safety Features: Amplifier over-current protection, motion limit micro-switches & cushions. In firmware (complete system only): relative displacement protection, over-speed protection, i^2t thermal protection
Spring Adjustment Ratio: 2:1 (certain configurations)	

Easily Transforms to Twelve Distinct Plants
(sixteen plants with optional third mass)

Plant Models	 ***Spring / mass / damper***	 ***Free - constrained, 2 DOF***	 ***Constrained - constrained, 2 DOF***
Additional Configurations			
Time Domain Equations*	$m\ddot{x}(t) + c\dot{x} + kx(t) = F(t)$	$m_1\ddot{x}_1(t)+k_2x_1(t)-k_2x_2(t) = F(t)$ $m_2\ddot{x}_2(t)+c\dot{x}_2(t)-k_2x_1(t)+(k_2+k_3)x_2(t) = 0$	$m_1\ddot{x}_1(t)+(k_1+k_2)x_1(t)-k_2x_2(t) = F(t)$ $m_2\ddot{x}_2(t)+c\dot{x}_2(t)-k_2x_1(t)+(k_2+k_3)x_2(t) = 0$
S-Domain Equations*	$\frac{x(s)}{F(s)} = \frac{1}{ms^2+cs+k}$	$\frac{x_1(s)}{F(s)} = \frac{m_2s^2+cs+k_2+k_3}{D(s)}$, $\frac{x_2(s)}{F(s)} = \frac{k_2}{D(s)}$ $D(s) = (m_1s^2+k_2)(m_2s^2+cs+k_2+k_3) - k_2^2$	$\frac{x_1(s)}{F(s)} = \frac{m_2s^2+cs+k_2+k_3}{D(s)}$, $\frac{x_2(s)}{F(s)} = \frac{k_2}{D(s)}$ $D(s) = (m_1s^2+k_1+k_2)(m_2s^2+cs+k_2+k_3) - k_2^2$
Characteristics	• Classic damped oscillator. • Pole excess = 2. • Configurable to type 0,1, or 2 system.	• Two damped modes. • x_1/F: "Damped" zero, pole excess = 2. • x_2/F: "no zeros, pole excess = 4. • Configurable to type 0,1, or 2 system.	• Two damped modes. • x_1/F: "Damped" zero, pole excess = 2. • x_2/F: "no zeros, pole excess = 4. • All configurations type 0.

*Three mass Model 210a has dynamic order up to six with three oscillatory modes.