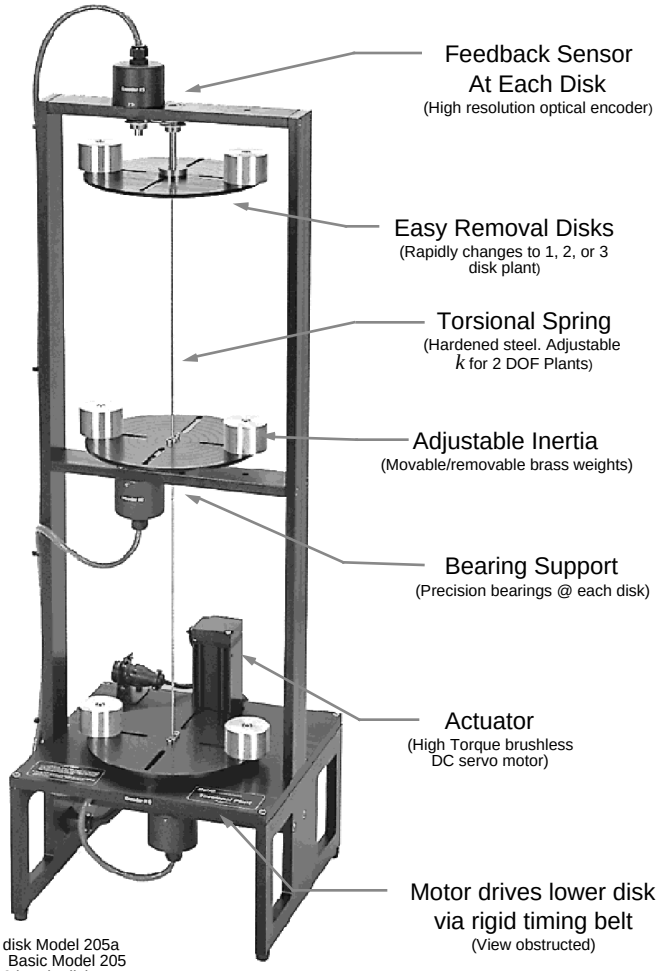
Model 205
Torsional Apparatus



Three disk Model 205a shown. Basic Model 205 has 2 inertia disks

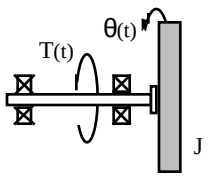
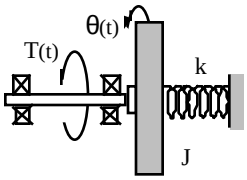
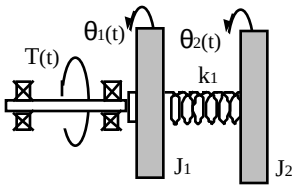
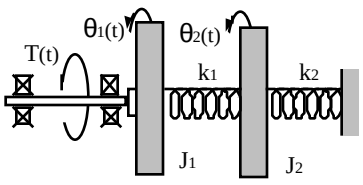
The Model 205 apparatus is a highly versatile platform that is ideal for introductory undergraduate lab use and intermediate controls study. It has also been used extensively in advanced research. In its several configurations, this system represents a broad and important class of practical plants including: rigid bodies, flexibility in drives, and coupled discrete vibrating systems. It easily transforms into second, fourth, and sixth (optional) order plants with collocated or noncollocated sensor / actuator control. An optional secondary drive may be positioned at any output (disk) to create a MIMO plant (requires *Executive USR*™ software) and provides for the study of disturbance rejection.

The ability to readily adjust physical parameters such as inertia values and spring constants make it ideal for multiple student work group assignments. This apparatus closely follows its dynamic model and the theoretical predictions of open and closed loop behavior provided in the manual. It has proven to be highly robust and reliable in the field.

Configurations: 6 std, 9 with optional 3rd disk, 18 with secondary drive accessory
Dynamics: Adjustable to 2nd, 4th, and 6th (3 disk option) order, Systems types 0 and 2
I/O: SISO, SIMO, MIMO (with sec. drive accessory)
Poles and Zeros: Adjustable 0.8-7 Hz
Inertia Adjustment Ratio: 10:1
Spring Adjustment Ratio: 2:1 (certain configurations)
Feedback: High resolution encoder (16,000 count/rev)
Actuator: High torque brushless motor, 2.0 N-m
Bench-top size: 30x30x96 cm. (12x12x36 in.)
Safety Features: Amplifier over-current protection. In firmware (complete system only): relative displacement (spring) protection, over-speed protection, i^2t thermal protection

Easily Transforms to 6 Distinct Plants That Include...

(Nine plants with optional third disk*)

Plant Models	 ***Rigid body***	 ***Free-clamped***	 ***Free-free, 2 DOF***	 ***Free-clamped, 2 DOF***
Time Domain Equations	$J\ddot{\theta}(t) = T(t)$	$J\ddot{\theta}(t) + k\theta(t) = T(t)$	$J_1\ddot{\theta}_1(t) + k(\theta_1(t) - \theta_2(t)) = T(t)$ $J_2\ddot{\theta}_2(t) + k(\theta_2(t) - \theta_1(t)) = 0$	$J_1\ddot{\theta}_1(t) + k_1(\theta_1(t) - \theta_2(t)) + k_2\theta_1(t) = T(t)$ $J_2\ddot{\theta}_2(t) + k_1(\theta_2(t) - \theta_1(t)) + k_2\theta_2(t) = 0$
S-Domain Equations	$\frac{\theta(s)}{T(s)} = \frac{1}{J s^2}$	$\frac{\theta(s)}{T(s)} = \frac{1}{J s^2 + k}$	$\frac{\theta_1(s)}{T(s)} = \frac{J_2 s^2 + k}{D(s)}$, $\frac{\theta_2(s)}{T(s)} = \frac{k}{D(s)}$ $D(s) = s^2(J_1 J_2 s^2 + (J_1 + J_2)k)$	$\frac{\theta_1(s)}{T(s)} = \frac{J_2 s^2 + k_1 + k_2}{D(s)}$, $\frac{\theta_2(s)}{T(s)} = \frac{k_1}{D(s)}$ $D(s) = J_1 J_2 s^4 + (J_1(k_1 + k_2) + J_2 k_1) s^2 + k_1 k_2$
Characteristics	• Rigid body model. • Type 2 system. • See page 5.	• Classic spring-mass oscillator • Type 0 system • Single vibration mode	• Rigid body plus 1 oscillatory mode. • Type 2 system. • θ_1/T: 2 imag zeros, pole excess = 2 • θ_2/T: no zeros, pole excess = 4	• 2 oscillatory modes. • Type 0 system. • θ_1/T: 2 imag zeros, pole excess = 2 • θ_2/T: no zeros, pole excess = 4

* Three disk Model 205a plant provides sixth dynamic order with third normal mode.