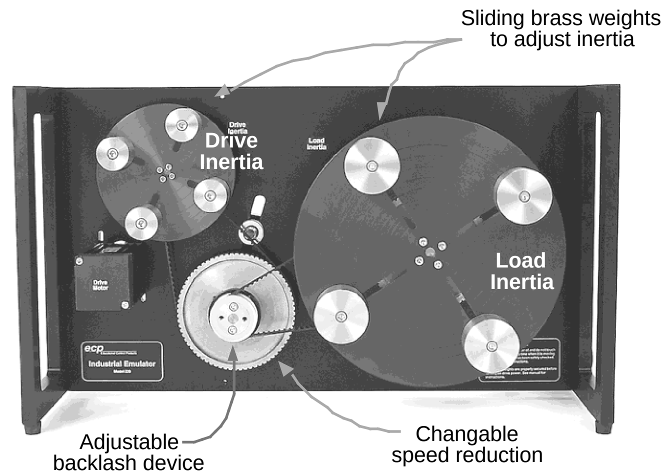
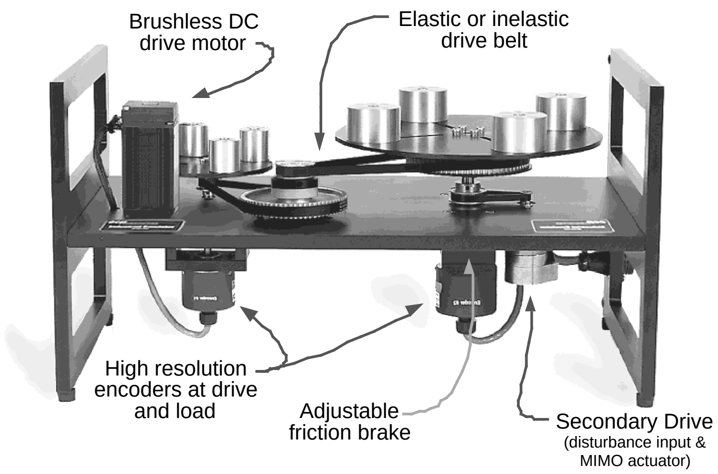
Model 220
Industrial Plant Emulator



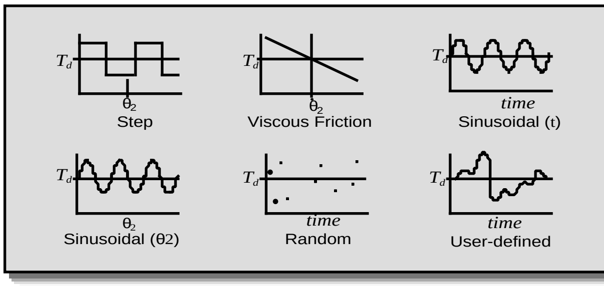


Testbed for Practical Control Training

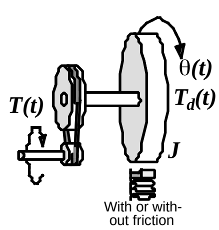
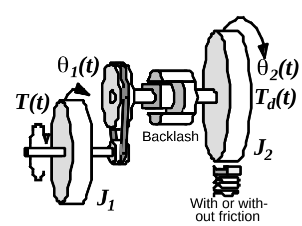
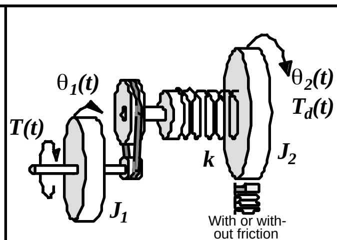
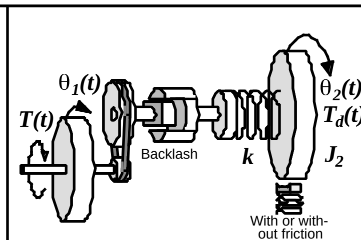
This system is ideal for teaching practical control of modern industrial equipment such as spindle drives, turntables, conveyors, machine tools, and automated assembly machines. Such plants are readily emulated using the many available configurations of the apparatus. Its adjustable dynamic parameters, and ability to introduce or remove non-ideal properties in a controlled manner make it a perfect selection for industrial servo control training. A built-in secondary drive provides for programmable disturbance inputs and with the optional Executive USR™ software, the apparatus becomes a full MIMO testbed.

Actuator Inertia, J_1:	Adjustable, .0004 to .00245 kg-m²
Load Inertia, J_2:	Adjustable, .005 to .025 kg-m²
Gear ratio (GR):	6 speeds from 1.5:1 to 24:1
Backlash:	Adjustable, 0 to 90 motor degrees
Drive flexibility:	Adjustable, Rigid to 1.0 Hz flex freq.
Coulomb friction brake:	Adjustable, 0 to > 10 N-m
I/O: SISO, SIMO, MIMO	
Feedback: High resolution encoder, 16,000 counts/rev.	
Actuator: High torque brushless DC servo motor, 2.0 N-m	
Secondary (disturbance) Drive: High torque brushless , 2.0 N-m	
Bench-top size: 30x51x12 cm. (12x20x12 in.)	
Safety Features: Plexiglass® cover, amplifier over-current protection. In firmware (complete system only): relative displacement protection, over-speed protection, i²t thermal protection	

Programmable Disturbance Torques



Introduce or Remove Non-ideal Properties

Plant Model	 **Basic Rigid Body**	 **Drive / Load with Backlash**	 **Drive / Load with Flexibility**	 **Drive / Load with Backlash & Flexibility**
"Exact" Time Domain *(expressions do not include all introducible parameters)*	$J\ddot{\theta} + c\dot{\theta} = n_g T$ where n_g is the gear ratio	$J_2\ddot{\theta}_2 + c_2\dot{\theta}_2 + f_2 sign(\dot{\theta}_2) = F_{bklsh}(\theta_2-\theta_1) * n_g(T - J_1\ddot{\theta}_1)$ where: $F_{bklsh}(\bullet)$ =0 when 0<•< backlash, =1 otherwise; f_2 is the Coulomb friction coef. Friction only at θ_2 assumed	$J_1\ddot{\theta}_1 + c_1\dot{\theta}_1 + k\left(n_g^{-2}\theta_1 - n_g^{-1}\theta_2\right) = T$ $J_2\ddot{\theta}_2 + c_2\dot{\theta}_2 + k(\theta_2 - n_g^{-1}\theta_1) = 0$	$J_1\ddot{\theta}_1 + c_1\dot{\theta}_1 + f_1 sign(\dot{\theta}_1) + F_{bklsh}(\theta_2-\theta_1) * k\left(n_g^{-2}\theta_1 - n_g^{-1}\theta_2\right) = T$ $J_2 n_g^2\ddot{\theta}_2 + c_2\dot{\theta}_2 + f_2 sign(\dot{\theta}_2) + F_{bklsh}(\theta_2-\theta_1) * k(\theta_2 - n_g^{-1}\theta_1) = 0$
S-Domain *(Nonlinear terms linearized)*	$\frac{\theta_1(s)}{T_D(s)} = \frac{1}{s((J_2+n_g^2 J_1)s + c_2)}$ $\theta_1 = n_g\theta_2$		$\frac{\theta_1(s)}{T(s)} = \frac{J_2 s^2 + c_2 s + k}{D(s)}$ $\qquad \frac{\theta_2(s)}{T(s)} = \frac{k/n_g}{D(s)}$ $D(s) = J_1 J_2 s^4 + (J_1 c_2 + J_2 c_1)s^3 + (J_1 k + J_2 n_g^{-2} k + c_1 c_2)s^2 + (c_1 k + c_2 n_g^{-2} k)s$	