

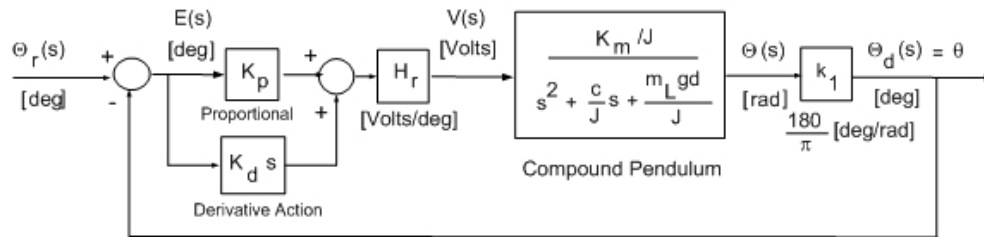
## Homework: Pole Placement and PID Simulation

1. In Lab 5, you designed a pole placement controller for the following system

$$\frac{\Theta(s)}{V(s)} = \frac{1.89}{s^2 + 0.039s + 10.77} = G_{ol}(s)$$

Create a pole placement controller in Simulink so that the settling time  $t_s = 3.0$  sec with damping  $\zeta = 0.4$ . Submit and/or answer the following:

- Simulink block diagram (use screen capture) (5 points)
  - Printout of Matlab code for pole and gain calculations (5 points)
  - Screen capture displaying the resulting poles and gains from Matlab code (5 points)
  - Scope output hardcopy (angle versus time response) to a 2.0 Volt step input (5 points)
2. Given  $k_1 G_{cp} H_r = \frac{10.823}{s^2 + 0.039s + 10.77}$  where  $G_{cp}$  represents the compound pendulum block, the following is a block diagram of PD control:



Where recall that:

$L$	Bar length	0.495	$m$	$J$	Moment of Inertia	0.0090	$kgm^2$
$d$	Pivot to CG distance	0.023	$m$	$c$	Viscous damping	0.00035	$Nms / rad$
$m_L$	Mass of pendulum	0.43	$kg$				

- A. Show that the closed-loop transfer function is given by (10 points)

$$\frac{\Theta_d}{\Theta_r} = \frac{10.823(K_p + K_d s)}{s^2 + (0.039 + 10.823K_d)s + (10.77 + 10.823K_p)} = G_{cl}$$

- Look up the Final Value Theorem and state what it is (5 points)
- Use the Final Value Theorem to show  $\theta_d(\infty) \approx 20$  when  $K_p$  is large and a step input  $\Theta_r(s) = 20/s$  is applied to the system in Question A above (5 points)
- Provide a hard copy printout of the scope output using gains  $K_p = 0.25$ ,  $K_D = 0.5$  (5 points)
- Provide a set of gains so that the settling time is less than 3.0 seconds and no overshoot. Include a hard copy printout of the scope output at these gains (5 points)