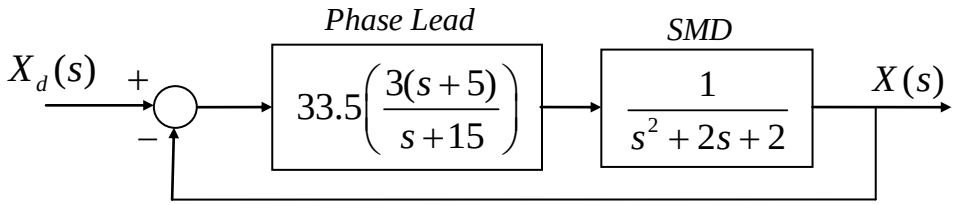
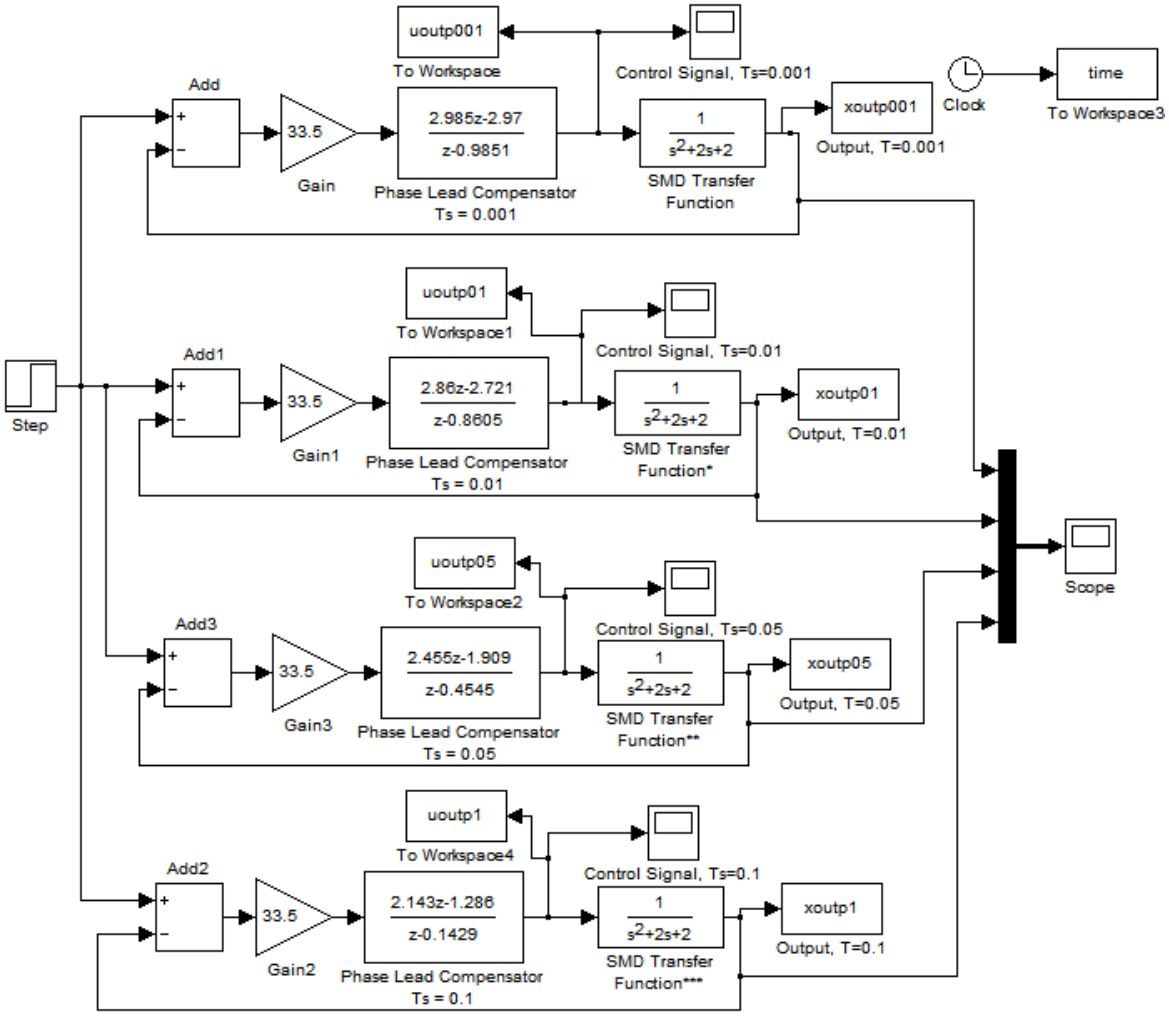
ME 4710 Motion and Control
Example: Phase Lead Control of a Spring-Mass-Damper

- ***Position control*** of a spring-mass-damper system using a ***continuous*** phase-lead compensator is shown below.



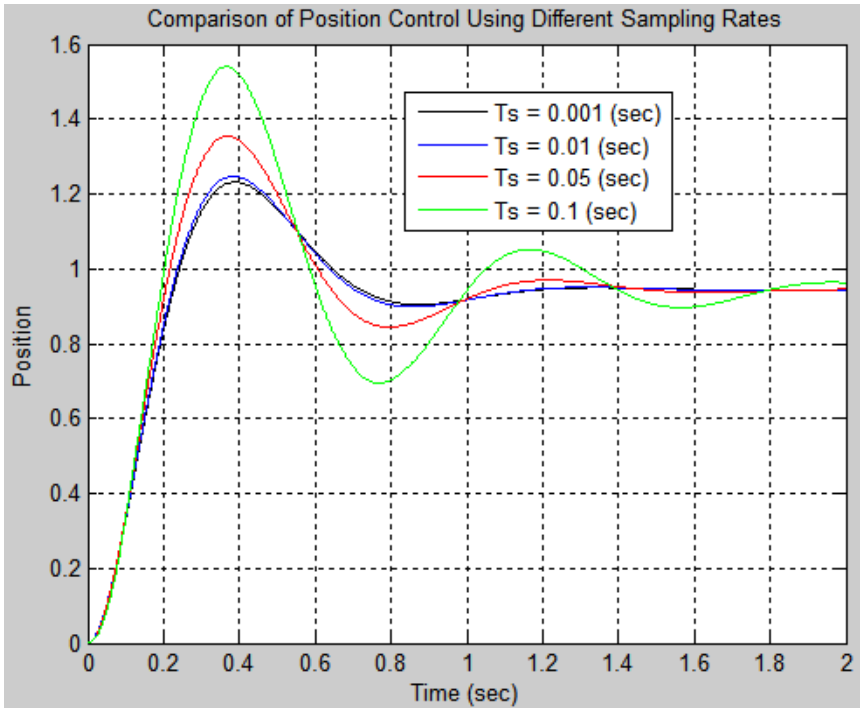
Closed-Loop Position Control of a Spring-Mass-Damper System

- Here, we implement the compensator in ***discrete form*** using ***Tustin's approximation*** at sampling times of $T = 0.001$ (sec), $T = 0.01$ (sec), $T = 0.05$ (sec), and $T = 0.1$ (sec).
- The ***performance*** of this ***system*** at the ***different sampling times*** is evaluated using the ***Simulink model*** shown below.

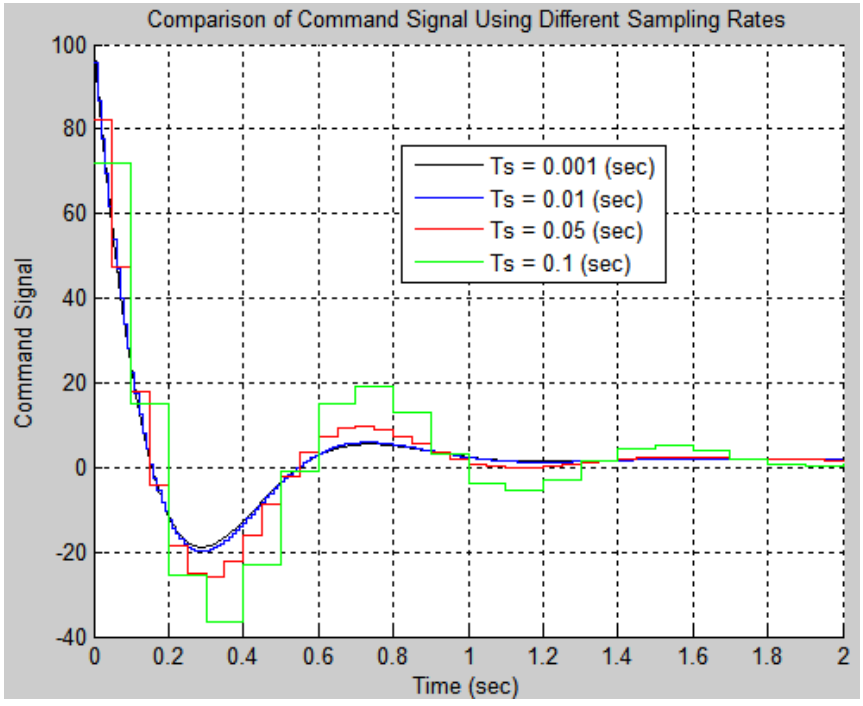


Simulink Model for Position Control of a Spring-Mass-Damper System

- The compensator is ***modeled*** as if it were ***implemented*** using digital hardware at each of the ***four sample rates***, and the ***SMD*** is ***modeled*** as a ***continuous system***.
- The ***results*** for the ***four different systems*** are shown below. Note that the position control ***degrades*** as the sampling time becomes ***too large***.



Comparison of Position Control for the Different Sample Times



Comparison of Control Signals for the Different Sample Times

- In general, ***reasonable results*** are expected when the sample rate is ***at least 20 times*** the ***closed loop system bandwidth***. The Bode diagram of the closed loop system is shown below, indicating a ***bandwidth*** of approximately $10\ (\text{rad/s}) = 1.6\ (\text{Hz})$.

- This result suggests that the sample rate for this system should be at least $f = 20(1.6) \approx 32\ (\text{Hz})$. This correlates to ***sample times*** of $T \leq 0.03\ (\text{sec})$. This is consistent with the results shown above.