

1. Bollinger 2.2.

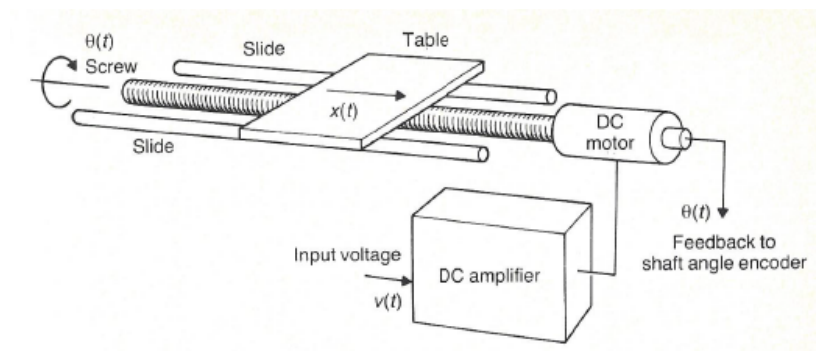
The positioning table shown in Figure below can be modeled using the following equations:

$$0.02 \frac{d^2 \theta(t)}{dt^2} + \frac{d\theta(t)}{dt} = 10v(t)$$

$$x(t) = 5\theta(t)$$

Find the difference equation relating output $x(t)$ to input $v(t)$ for a sample period of $T=0.01s$.

- By direct conversion to difference equation.
- By using the forward difference of the Laplace transform.
- By using the backward difference of the Laplace transform.
- By using the bilinear difference of the Laplace transform.



2. Determine the stability of the following difference equations.

- $y_n - 1.6y_{n-1} + 1.13y_{n-2} = 0$
- $y_{n+3} - 2y_{n+2} + 1.5y_{n+1} - 0.5y_n = 0$
- $y_n = y_{n-1} + 1.05x_n - x_{n-1}$

3. Bollinger 3.10

The response sequence for a system with a unit step input is described by the following equation.

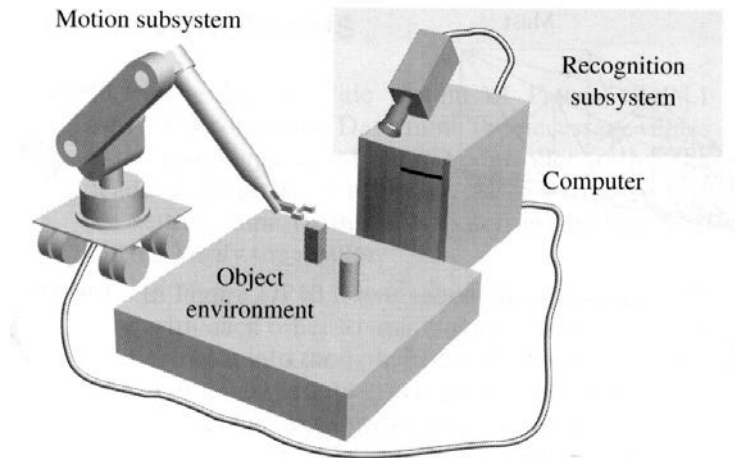
$$c_n(t) = \frac{9}{(1-B)(1-0.1B)} S_n \left(= \frac{9}{(1-z^{-1})(1-0.1z^{-1})} S_n \right) \left(\text{unit step input} = \frac{1}{1-z^{-1}} \right)$$

- Determine the response sequence using long division and plot the response.
- Determine the response by employing partial fraction expansion and Table 3.1.
- Determine the final value of the response using the final value theorem.

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4. A mobile robot using a vision system as the measurement device is shown in Figure below.

The robot open system dynamics is given by $G_p(s) = \frac{1}{(0.5s + 1)}$.



- Design a PI controller such that the percent overshoot for a step input is 5% or less and the settling time (2%) is less than 6 seconds.
- Simulate the control system response in continuous domain.
- Obtain the closed loop transfer function in discrete domain, including zero-order-hold dynamics between the controller and the servo system (as shown below). Use backward transformation to convert the controller.
- Simulate the response to a unit step input in the discrete domain to check if the original performance specification is satisfied.

