# Empirical Model Identification - Ch. 6

Empirical modelling provides an approximate model when a full, detailed model may not be possible.

In this approach, we apply a step change $\delta$ to an input and then record the response. We use the response to produce an approximate first order with dead-time model.

We <u>assume</u> that

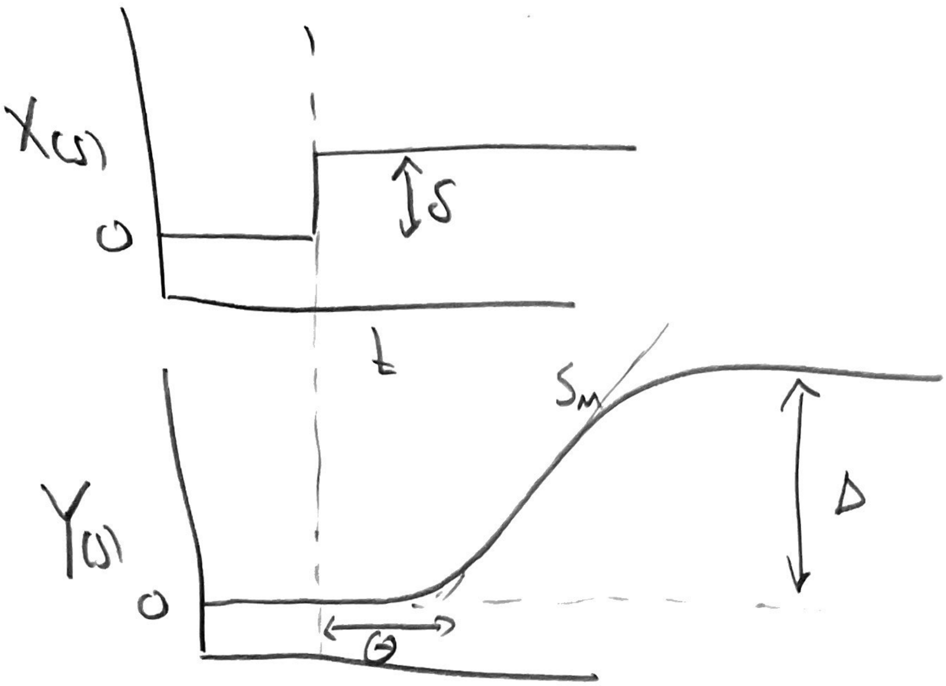
$$\underset{\text{output}}{Y(s)} = \frac{K_p e^{-\theta s}}{\tau s + 1} \underset{\text{input}}{X(s)}$$

The approximate model has 3 parameters: $K_p$, $\theta$, & $\tau$.

We need 3 equations to determine those parameters

Process

# Process Reaction Curve




Eqn 1: $K_p = \frac{\Delta}{\delta}$

Eqn 2: $\tau = \frac{\Delta}{S_M}$ where $S_M$ is the max slope

Eqn 3: $\theta$ is determined graphically from the intercept of the tangent $S_M$ with the initial value.

(See book for derivation)

Using this method, we can model a complex process with a first order plus dead time model.

A second method is to use the values $\Delta$, $\tau_{28\%}$, and $\tau_{63\%}$ where $\tau_{28\%}$ and $\tau_{63\%}$ are the times when the output reaches 28 and 63% of the final steady state value.

Eqn 1: $$k_p = \frac{\Delta}{\delta}$$

Eqn 2: $$\tau = 1.5(\tau_{63\%} - \tau_{28\%})$$

Eqn 3: $$\theta = \tau_{63\%} - \tau$$

Derivation of Eqns 2 + 3:

For first order model
$$Y'(\theta+\tau) = 0.632\Delta$$
$$Y'(\theta+1/3\,\tau) = 0.283\Delta$$

Therefore
$$\tau_{63\%} = \theta+\tau \qquad \tau_{28\%} = \theta + 1/3\,\tau$$

This gives
$$\tau = 1.5(\tau_{63\%} - \tau_{28\%}) \cdot \theta = \tau_{63\%} - \tau$$