

## Lecture Module - Alternate Model Forms

ME3050 - Dynamic Modeling and Controls

Mechanical Engineering

Tennessee Technological University

### Topic 1 - Equivalent Models

## Alternate Model Forms

- Equivalent Model Concept
- Differential Equations
- Transfer Functions and Block Diagrams
- State-Space (Variable) Models
- Computer Models

## Equivalent Model Concept

A mathematical model is an expression derived from basic principles that describes a physical or simulated system.

Models appear in different forms.

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*Each form has its own advantages and disadvantages. We can convert one form into another, with differing degrees of difficulty. - Palm*

# Equivalent Model Concept

## Standard Form of an ODE

Ordinary Differential Equations are written in the following form.

$$a_n \frac{dy^{(n)}}{d^{(n)}x} + a_{n-1} \frac{dy^{(n-1)}}{d^{(n-1)}x} + \dots + a_2 \frac{dy^2}{d^2x} + a_1 \frac{dy}{dx} + a_0 y = f(x)$$

The apostrophe is commonly used for the derivative.

$$a_n y^{(n)} + a_{n-1} y^{(n-1)} + \dots + a_2 y'' + a_1 y' + a_0 y = f(x)$$

The overdot notation implies that time is the independent variable.

$$a_2 \ddot{y} + a_1 \dot{y} + a_0 y = f(t)$$

Equivalent Model Concept

**Differential Equations**

Transfer Functions and Block Diagrams

State-Space (Variable) Models

Computer Models

# Differential Equations

# Transfer Functions and Block Diagrams

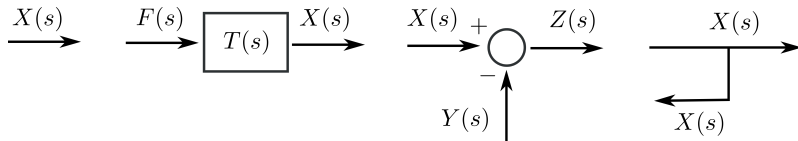
The transfer function is a way of describing a system that can be used to analyze the system response to an external input with the assumption of zero initial conditions.

$$T(s) = \frac{X(s)}{F(s)}$$

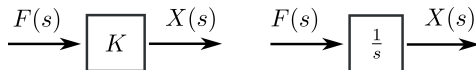
Does this look familiar? How can we find the transfer function?

# Transfer Functions and Block Diagrams

A block diagram is a visual representation of the transfer function concept. Here are the four basic symbols.



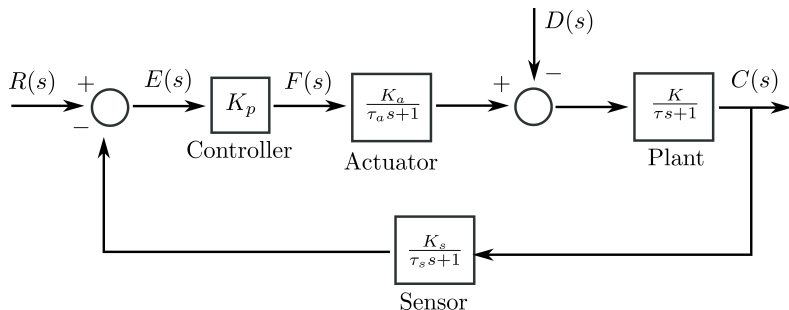
Mathematical operations can be represented as block diagrams.





# Transfer Functions and Block Diagrams

Complex systems can be described by block diagrams.



# State-Space (Variable) Models

# Computer Models