

Lecture Module - Fluid Systems

ME3050 - Dynamic Modeling and Controls

Mechanical Engineering

Tennessee Technological University

Topic 1 - Basic Concepts

Fluid Systems

- Definitions and Concepts
- Conservation of Mass
- Fluid Capacitance and Resistance
- Dynamic Models of Hydraulic Systems
- Examples

Definitions and Concepts

A fluid system uses one or more fluids to achieve its purpose.

Examples:

- Fluid Damper in Suspension (Shock Absorber)
- Hydraulic Front Loader (Tractor)
- Fuel Delivery System
- HVAC System

Definitions and Concepts

Fluid systems can be categorized as either hydraulic or pneumatic systems.

Hydraulic:

Pneumatic:

For incompressible fluids, the conservation of mass becomes the:

_____ of _____.

Definitions and Concepts

The mass density and the volume flow rate can be used to find the volume flow rate.

$$q_m = \rho q_v$$

Conservation of Mass

The conservation of mass is stated below.

$$\dot{m} = q_{mi} - q_{mo}$$

If the fluid is incompressible, this relation can be re-written as the conservation of volume.

$$\dot{m} = \rho \dot{V} \implies q_{mi} = \rho q_{vi} \text{ and } q_{mo} = \rho q_{vo}$$

$$\rho \dot{V} = \rho q_{vi} - \rho q_{vo}$$

$$\dot{V} = q_{vi} - q_{vo}$$

Fluid Capacitance and Resistance

Fluid systems can be compared to equivalent electrical systems.

Analogous Quantities

Fluid Mass, m	Charge, Q
Mass Flow Rate, q_m	Current, i
Pressure, p	Voltage, v
Fluid (linear) Resistance, R	Electrical Resistance, R
$R = p/q_m$	$R = v/i$
Fluid Capacitance, C	Electrical Capacitance, C
$C = m/p$	$C = Q/v$
Fluid inductance, L	Electrical Inductance, L
$L = p/\left(\frac{dq_m}{dt}\right)$	$L = v/\left(\frac{di}{dt}\right)$

Fluid Capacitance and Resistance

Fluid Resistance is the relation between pressure and mass flow rate.

Fluid Capacitance is the relation between pressure and

_____.

Fluid Capacitance and Resistance

Can you relate Kirchoff's laws to a fluid system?

The _____ law is analogous to Kirchoff's voltage law (KVL).

The _____ law is analogous to Kirchoff's current law (KCL).

Dynamic Models of Hydraulic Systems

Examples