

A quick review of lumped-parameter modeling of mechatronic systems

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Most systems of engineering interest are very complex. In fact, too complex to compute, if we want to be completely precise.

However, many of these systems can be "lumped" into several parameters which can be mathematically described and still represent most of the interesting behavior of the system.

Electrical systems

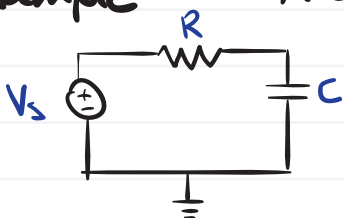
There are many important electrical components that have lumped-parameter models. The three most important (to who? ... me, I guess) components are listed below along with their **elemental equations** in terms of the electrical power flow variables v (voltage) and i (current).

Resistor	$\frac{R}{\text{---}\text{---}\text{---}}$
Capacitor	$\frac{C}{\text{---}\text{---}}$
Inductor	$\frac{L}{\text{---}\text{---}\text{---}}$

For electrical circuits, the compatibility + continuity equations are just **Kirchoff voltage + current laws**.

Let's analyze an RC circuit as a refresher.

Example Find the transfer function $H(s) = \frac{V_c(s)}{V_s(s)}$.



1. Linear graph + normal tree.

2. Variables + system order.

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State variables:

state vector:

system order:

3. Elemental equations.

4. Continuity equations.

5. Compatibility equations.

6. Algebra (state equations).

7. Standard form.

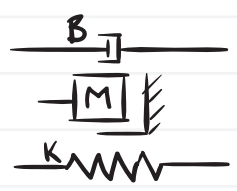
8. Transfer function.

Mechanical translational systems

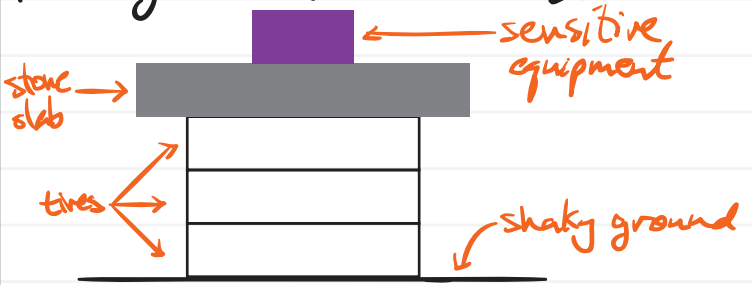
The mechanical translational power flow variables are v (velocity) and f (force). These variables are related

in the mechanical elemental equations Here are the three most common translational lumped-parameter elements with their elemental equations.

Damper
Mass
Spring



Example Define a lumped-parameter model of a makeshift vibration-isolation table made of a large stone slab resting on old tires. Draw a linear graph + normal tree.



Mechanical rotational systems

The mechanical rotational power flow variables are Ω (angular velocity) and T (torque). These variables are related in the mechanical elemental equations. Here are the three most common rotational lumped-parameter elements with their elemental equations.

Rotational Damper
Moment of Inertia
Rotational Spring

