01.7 intro.genvars Generalized through- and across-variables

1 We have considered mechanical translational, mechanical rotational, and electronic systems—which we refer to as different **energy domains**. There are analogies among these systems that allow for generalizations of certain aspects of these systems. These generalizations will allow us to use a single framework for unifying the analysis of these (and other) dynamic systems.

2 There are two important classes of variables common to lumped-parameter dynamic systems: *across-variables* and *through-variables*.

3 An **across-variable** is one that makes reference to two nodes of a system element. For instance, the following are across-variables:

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We denote a **generalized across-variable** as $\mathcal{V}$.

4 A **through-variable** is one that represents a quantity that passes through a system element. For instance, the following are through-variables:

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We denote a **generalized through-variable** as $\mathcal{F}$.

5 The **generalized integrated across-variable** $\mathcal{X}$ is

$$\mathcal{X} = \int_0^t \mathcal{V}(\tau) d\tau + \mathcal{X}(0). \tag{1}$$

6 The **generalized integrated through-variable** $\mathcal{H}$ is

$$\mathcal{H} = \int_0^t \mathcal{F}(\tau) d\tau + \mathcal{H}(0). \tag{2}$$

7 For mechanical and electronic systems, power $\mathcal{P}$ passing through a lumped-parameter element is

$$\mathcal{P}(t) = \mathcal{F}(t)\mathcal{V}(t). \tag{3}$$

8 These generalized across- and through-variables are sometimes used in analysis. However, the key idea here is that there are two classes of power-flow variables: across and through. These two classes allow us to strengthen the sense in which we consider different dynamic systems to be analogous.