2.4 Systematic Linear Graph Modeling

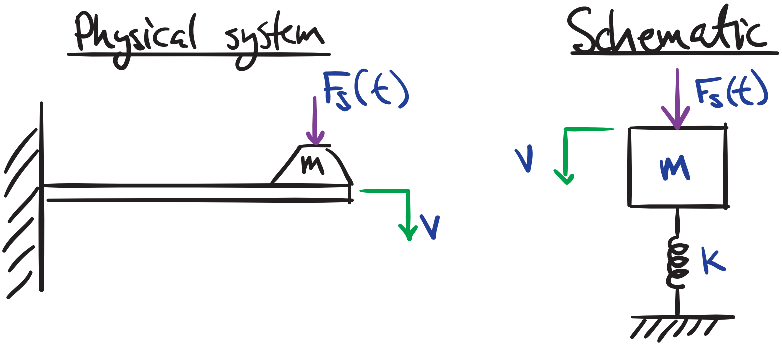
A **system graph** is a representation of a physical system as a set of interconnected linear graph elements. The construction of a system graph requires a number of engineering decisions. In general, we can use the following procedure.

1. Define the system boundary and analyze the physical system to determine the essential features that must be included in the model, especially:
    1. inputs,
    2. outputs,
    3. energy domains, and
    4. key elements.
2. Form a schematic model of the physical system and assign schematic signs according to the sign convention of **??**.
3. Determine the necessary lumped-parameter elements representing the system's
    1. energy sources,
    2. energy storage, and
    3. energy dissipation.
4. Identify the across-variables that define the linear graph nodes and draw a set of nodes.
5. Determine appropriate nodes for each lumped element and include each element in the graph.
6. Assign linear graph signs according to the sign convention of **??**.

The first three of these steps are the hardest. Considerable physical insight is required to construct an effective model. Often it is helpful—if not necessary—to have experimental results to guide the process.

Example 2.4

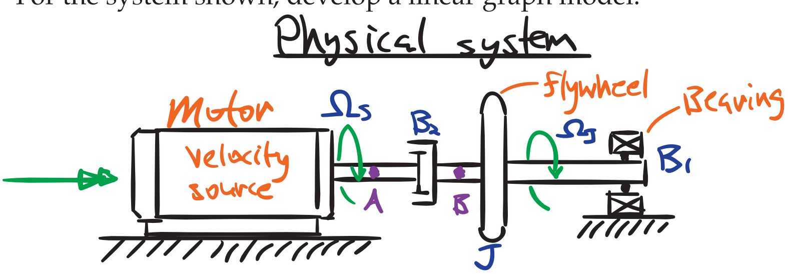
For the system shown, develop a linear graph model.



linear graphs

Example 2.5

For the system shown, develop a linear graph model.

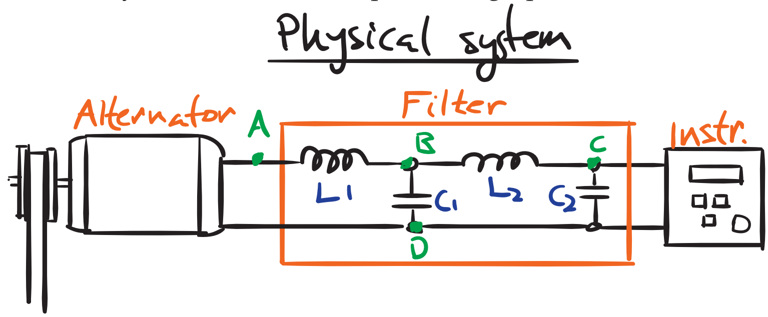


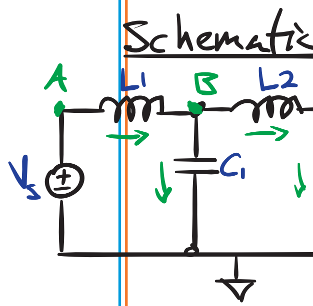
linear graphs

and more

Example 2.6

For the system shown, develop a linear graph model.





linear graph

something

2.5 Problems

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Problem 2.1 PLAYMATE Consider the illustration of figure 2.7 in which a bending plate scale is to have a heavy load placed upon it. Such scales measure the weight of the load by measuring the strain on the sensors and electronically converting this to the weight placed on the plate. (It goes without saying that calibration is required for such systems.)

It takes time for the system to come to equilibrium, during which oscillation occurs. Develop a one-dimensional lumped-parameter model of the mechanical aspect of the system and its applied load, via the following steps.

1. Declare what you will take to be the system and its input(s).
2. Declare a one-dimensional, mechanical, lumped-parameter model for the system. How might you determine the lumped-parameter model parameters (e.g. mass, spring constant, etc.)?
3. Draw a schematic of the lumped-parameter system model.
4. Draw a linear graph corresponding to your lumped-parameter model.

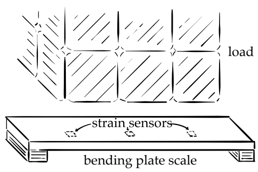

Figure 2.7. A bending plate scale with strain sensors and load.

Problem 2.2 NOD Consider the illustration of figure 2.8 in which a motor is on a machine and an instrument is atop a nearby workbench. The motor typically spins at a fixed velocity, generating a vibration that is transmitted through the machine and into the floor.

Suppose you are given the task of designing the feet of the instrument such that less than a certain amount of vibratory motion from the motor will be transmitted through the floor and workbench to the instrument.

Develop a one-dimensional lumped-parameter model of the mechanical aspect of the system via the following steps.

1. Declare what you will take to be the system and its input(s).