**Example 1:** Show that a sensor whose output is proportional to the integral of the input is linear. I.e., if is the physical property that activates the sensor, and the output voltage is , show that the output to a physical quantity is .

**Example 1 Solution:** The output to is

**Example 2:** Show that, if the output is , the sensor is not linear.

**Example 2 Solution:** The output to the sum of and is

This differs from the sum of the outputs by the term .

1. Show that (perhaps surprisingly) the characteristic is not linear, where and are constants.
2. Show that the Laplace transform is linear.
3. For the Wheatstone bride shown, with a supply voltage , derive the relationship between the voltage out () and the resistor values. I.e., use the basic Kirchov’s laws to show that
4. Assume that the bridge in the previous problem is initially balanced such that and . Now let change by . Find a new expression for in terms of , , and . (Answer: )
5. In most cases, the change in resistance will be small in comparison to the balanced resistor values. I.e. . Furthermore, for small , a Taylor series approximation of can be used: (If you don’t believe me, try it for, say ).

Use this expression and the result of the previous problem to find an approximate linear expression for . (Answer: )

1. Assume a bridge is initially balanced with , and is changed to 1050 . Find the exact solution for the output voltage with a 10 volt supply and compare it to the approximate solution given in the previous problem.

Recall

What is the error (expressed as percent) between the exact solution for and the approximate formula of Problem 5?

1. Modify the Wheatstone bridge equation

to replace the resistances and with impedances (change the s to s). Then assume that and . Determine an expression for the output voltage as changes to .

**Graduate Content**

1. A simple model of a neuron is based on the idea that the cell body integrates all signals from incoming axons, some of which are activating, while others are inhibiting, and generates an action potential when the voltage within the body becomes greater than a given threshold. The action potential lasts for a finite amount of time and then returns to a value below the threshold.

Construct a model of this behavior that may include (1) one or more summing integrators, (2) a Schmitt trigger, and/or (3) a one-shot.