Lab 20—Strain-Gauge Bridge Measurement

Purpose

We are going to set up a cantilever beam with four strain gauges. We will first use an ordinary digital voltmeter to measure the amount of imbalance in the bridge and relate this to the weight placed at the end of the beam. Then we'll add an op-amp to show how this improves the "range" and readability.

Deliverables

- Observation of the value of a "zero-able" bridge
- Bridge readings without and with amplification
- Measurement of several different weights to yield a graph of weight vs. voltage

Equipment

You'll need the cantilever beam, a large C clamp, and a partial set of weights. There are not enough weights for everyone to have a full set, so you'll need to share. You'll also need a small screwdriver, four clip leads, a 3-V battery, and your DMM, as well as a prebuilt op-amp board and a dual 6-V (nominal) battery. The setup is similar to Lab 13.

Procedure

Beam setup

1. Clamp the cantilever beam (Fig. 1) to the table. Don't squash any components or wires. The photo of Fig. 4 shows a correct setup.

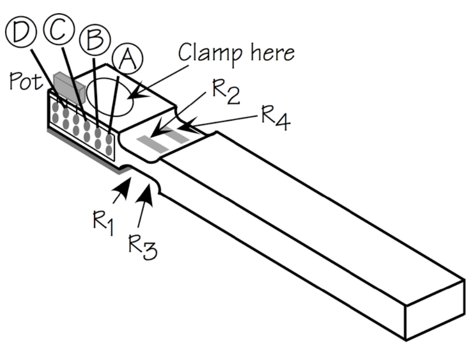

Fig. 1—Cantilever and strain gauges

2. The bridge circuit (Fig. 2) is already built onto the beam (Fig. 3). You will connect to V_s and V_b only.
3. Connect the 3-V (nominal battery supply to the V_s terminals of the bridge.

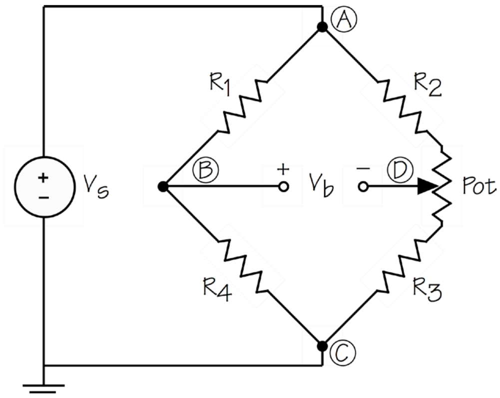

Fig. 2—Strain gauge bridge

Test a two-gauge circuit setup

The first test circuit uses only **two** gauges, R_1 (bottom) and R_4 (top). We will ignore gauges R_2 and R_3.

4. Use two clip leads to connect your DMM's red lead to pin B (V_b+) and the black lead to pin C (V_s–). Record the reading, which should be about 1.6 V..
5. Attach one large weight to the bridge. Please don't screw the weight tight—it will seize and be very hard to take off.
6. Record the weight and the voltage reading.
7. Remove the weight and keep it for the next part.

Test a four-gauge bridge setup

Now we'll test the full bridge circuit.

8. Move the black lead **of the DMM** from pin **C** (V_s–) to pin **D** (V_b–).

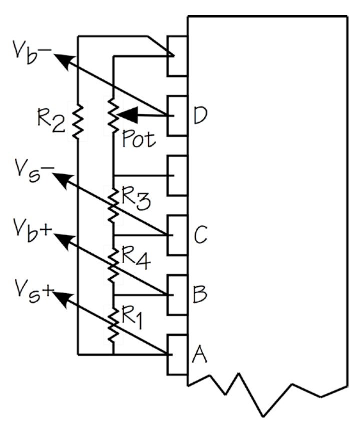

Fig. 3—Bridge connections

9. Null the bridge, i.e., adjust the pot on the bridge until the voltmeter reads 0. Flex the beam a *little* to check operation. Record the voltage.
10. Attach the same weight as before and record the reading. Comment on what you have just learned about the difference between the two measurement methods.

Add an op-amp to V_b

11. On the prebuilt op-amp board, insert a 1-kΩ resistor into jumper position A, a jumper into position B, and a 47-kΩ resistor into position D (see Fig. 5).

12. Connect the V_b terminals of the bridge to the input pins of the op-amp circuit using clip leads.

13. Connect the correct +6-V and –6-V batteries to the prebuilt op-amp board (see Fig. 5).

14. Connect your dmm to the op-amp board's output.

15. Rezero the bridge and check by flexing the beam. Record the voltage offset (if any), paying attention to sign. Get as many significant digits as possible.

16. Collect bridge data by using the various combinations of weights to complete the data table on the hand-in page. Please don't screw the weights tightly together.

17. Complete the data table by subtracting the offset, which was the reading of the voltmeter with no added weight.

18. Choose appropriate (and sensible) scale calibrations for the graph and properly label the axes.

19. Plot the data on this graph and draw a smooth curve.

Finishing

Hand in the completed hand-in page by the end of this lab session .

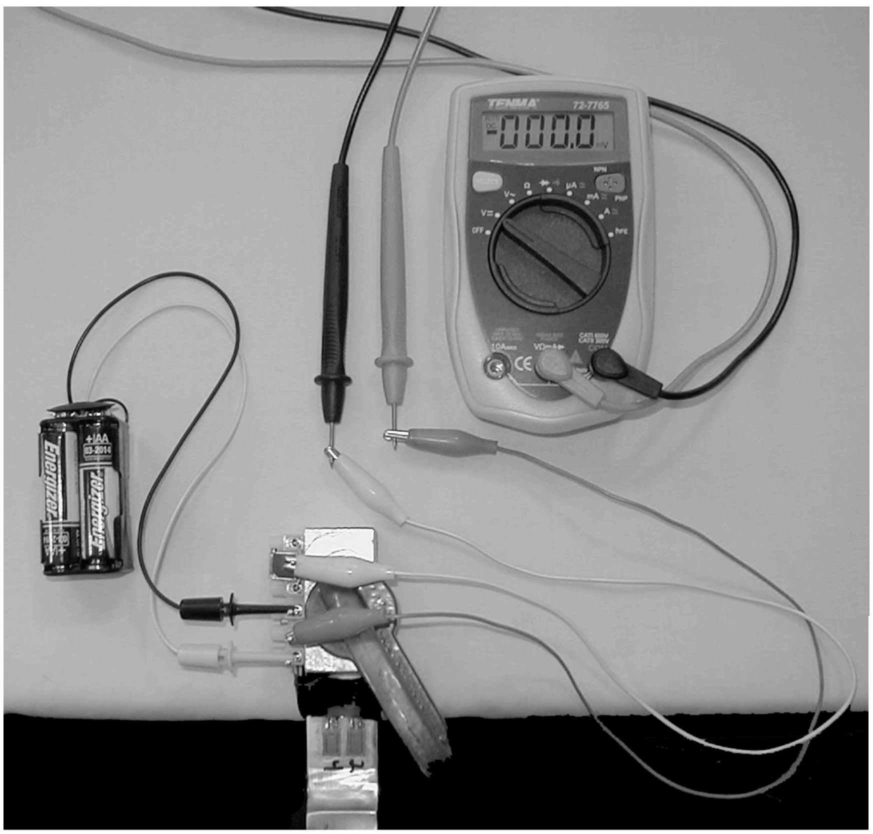

Fig. 4–Strain-gauge setup

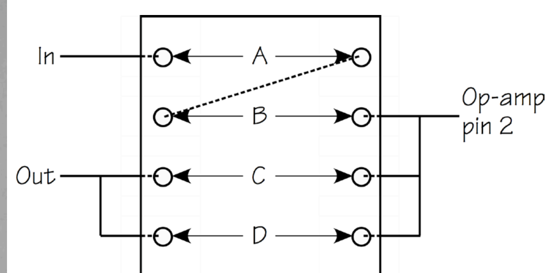

Fig. 5–Jumper positions

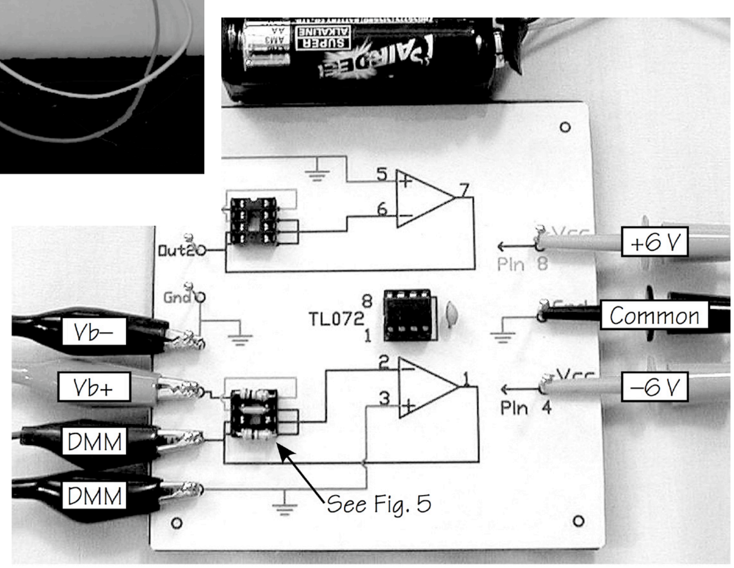

Fig. 6–Op-amp board with connections

$$\Delta R \approx S\varepsilon R$$

$$\text{1-arm: } V_b \approx \frac{\Delta R}{4R} V_s \quad (\Delta R \ll R)$$

$$\text{4-arm: } V_b \approx \frac{\Delta R}{R} V_s \quad (\Delta R \ll R)$$

Turn in this page with all required data, calculations, and discussion by the deadline given in the lab instructions.

By ____

____

____

Date ___________________________ Bench # __________

Bar # (not 120 or 350): ____________ **Bar type (120 or 350): ____________**

Added weight	**None**	**g**
Two-gauge voltage (B to C)	**V**	**V**
Bridge voltage (B to D)	**V**	**V**

What have you learned about the two measurement methods?

Weight combination	**None**	**Small**	**Small–medium**	**Small–large**	**Medium–large**
Labeled total weight (g)	**0**				
Voltage reading (mV)	(offset value)				
Corrected* voltage (mV)	**0**				

*Corrected = |Reading – Offset|