

Executive Summary

Team 1 has designed and constructed a digital postal scale utilizing a three point bending system. Specifications of the scale are as follows: measures weight from 0 - 4 pounds, has a resolution of $\frac{1}{2}$ ounce, accuracy of 0.5%, is readable up to 2 feet, fits into a shoe box of 15x8x5 inch dimensions, and is powered by two 9 V batteries. The housing and leg supports are constructed of oak. The strain bar, aluminum support, and platform-piston assembly are constructed of T-6061 aluminum. The circuit is built with three $120\ \Omega$ resistors, one $120\ \Omega$ strain gage, two 9 V batteries, a potentiometer, a $10\ \text{k}\Omega$ resistor, and a digital multi-meter (DMM). When weight is applied to the platform, the strain bar is elongated. The elongation of the strain bar causes a corresponding elongation in the strain gage, which makes the gage's resistance value rise. The strain gage is attached to the Wheatstone bridge, which becomes unbalanced when the strain gage's original resistance value changes. This unbalancing will cause a potential difference across two terminals of the bridge. This voltage difference is measured and displayed using the DMM.

Team 1's digital postal scale (See Figure 1) has been designed to meet all specified requirements (See Table 1).



Figure 1 – Digital Postal Scale

Characteristic	Specification
Capacity	0 - 4 lbs
Resolution	1/2 oz
Accuracy	0.50%
Readability	2 ft
Size	15x8x5 in shoe box

Table 1 – Design Specifications

The object to be weighed is placed on the round T-6061 aluminum platform. A cylindrical piston, also constructed of T-6061 aluminum, is bolted to the center of the platform. The piston's shape is conical at the bottom end, which causes the force generated by the applied weight to be concentrated to a single point on the strain bar. An integrated support with oak legs and an aluminum upper section holds both the platform 1/4 in. above the piston support. This space gives the platform room to slide as weight is applied, and also prevents overload of the strain bar, which could result in plastic deformation.

deformation.

The scale is divided into five subsystems: 1) Platform and Piston: 2) Strain Bar: 3) Support: 4) Electric Circuit: and 5) Housing.

The platform and piston assembly is constructed of T-6061 aluminum. The platform is 5 inches in diameter and 1/8 inch thick. The piston, which is 1/2 inch in diameter and 1 inch long, is bolted to the center of the platform (See Figure 2).

The strain bar is 5 inches long, 1/2 inch wide, 1/16 inch thick, and is also constructed of T-6061 aluminum (See Figure 3).

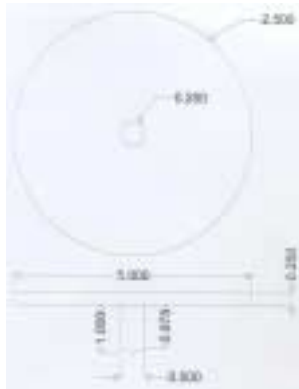


Figure 2 – Platform and Piston



Figure 3 – Strain Bar

The support system is constructed from two legs made of oak and an aluminum upper section screwed into the legs. The oak supports are 1x2x1 1/2 inches, with a 1/2 inch notch cut out (See Figure 4a). The aluminum support is made of T-6061 aluminum and has 5 1/2x1/2x1 inch dimensions (See Figure 4b).

The piston travels through a hole bored through the center of the aluminum support. There are two small holes at either end allow the support to be screwed down to the support legs.

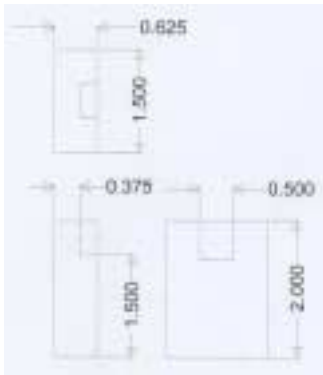


Figure 4a – Wooden Supports



Figure 4b – Aluminum Support

The electric circuit is built with three 120 Ω resistors, one 120 Ω strain gage, two 9 V batteries, one potentiometer, one 10K Ω resistor, and a DMM (See Figure 5).

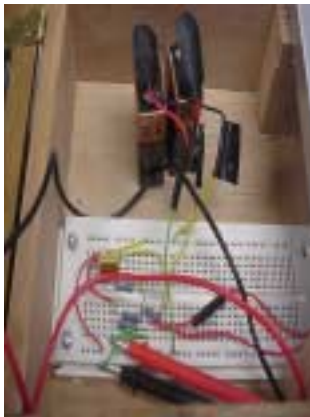


Figure 5 – Electric Circuit

The housing of the scale is constructed entirely of oak. The outer dimensions of the housing for the digital postal scale are 9 ½x6 ½x3 inches. The cut pieces were first glued, then nailed together into an open box. Hinges were attached to the lid and then to the appropriate place on the box. This hinged sections allows access to the circuit hidden inside the box (See Figure 6).

This drawing, shows all the components in the digital postal scale that

are needed for assembly

(See Figure 7).

For Team 1's testing and analysis, two trial runs were conducted. Different increments of weight from 0 to 4 pounds were placed on the platform. Readings (in tenths of millivolts) were obtained. With this data, graphs were plotted from the trial runs and compared to theoretical data obtained using equations (See Chart 1 & 2).

So far, Team 1 is on schedule. A few problems were encountered in obtaining aluminum parts from Chromalloy, which delayed manufacturing of the scale. Jason was in charge of getting the aluminum parts. Amela was designated to put the strain gages onto the strain bar. Amber built our oak wood housing. Ryan took on the task of drawing and scanning all the needed dimensions for the scale. Christina was responsible for buying all the electrical components for the circuit and all the materials needed for the housing.



Figure 6 – Housing/Assembled Scale



Figure 7 – Exploded View

Team 1 achieved the target design specifications, the scale well under the dimensions given. The key feature to Team 1's digital postal scale is that the hinged portion of the housing allows easier access to the electrical circuit. The advantages of this scale is that there is no use of an Operational Amplifier 741 (OP Amp), which allows easier control of the circuit. Difficulties encountered were putting on the strain gage on the strain bar. Also using the OP Amp 741.

So far, Team 1 has followed the timeline (See Figure 8). Team 1 is at the point where the indicated line is.

For Team 1's budget, since there are five members in this team, there is a budget of \$125.00 to spend on material to build the digital postal scale. The following table labels what Team 1 bought and how much money was spent. The total budget came to a total of \$121.00. There is about a \$4.00 allowance for any minor changes that needs to be added or changed (See Figure 9).

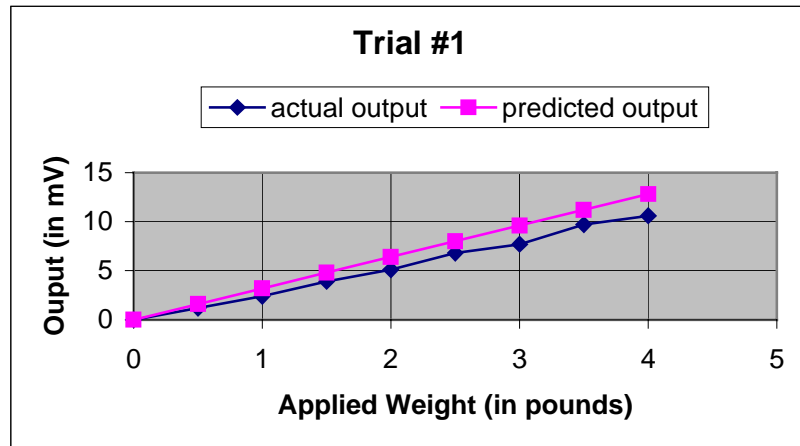


Chart 1 – Trial Run #1

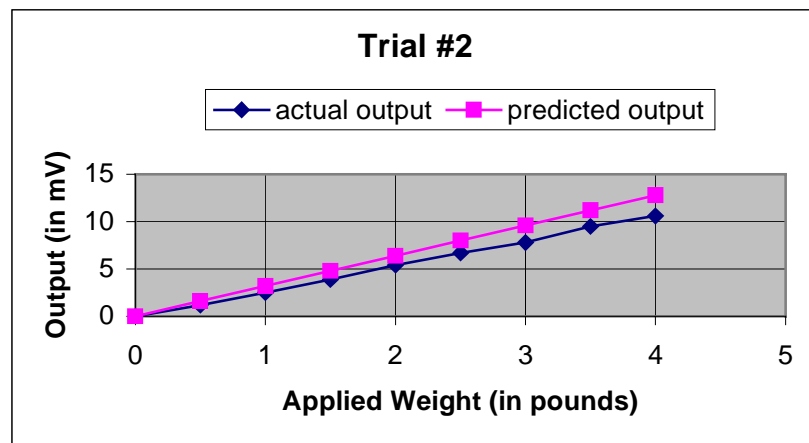


Chart 2 – Trial Run #2

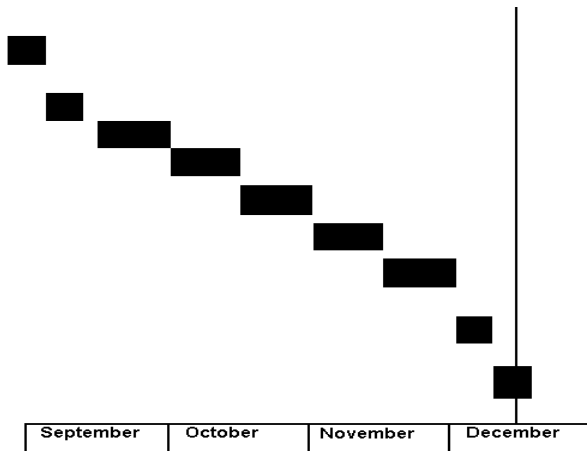


Figure 8 - Timeline

Object	Price
Digital Multi-Meter	\$18.00
Bread Board	\$13.00
Housing Parts	\$9.00
Strain Gages	\$12.00
Aluminum	\$40.00
Batteries	\$10.00
Electronic Parts	\$17.00
Hardware	\$2.00
TOTAL	\$121.00

Figure 9 – Budget Table

APPENDIX

References:

Dally, J. and Rocheleau, D., Introduction to Engineering Design, College House Enterprises, LLC, Knoxville, 1998.

Goldberg, D., Life Skills and Leadership for Engineers, McGraw-Hill, Inc., 1995.

Forrest, M., Engineer's Mini-Notebook, Op-Amp Circuits, Siliconcepts, 1985.

Equations:

ϵ = strain

$$\epsilon = 3WuS / 2bh^2 E$$

W = weight applied S=span of strain bar b=base h=height E=Young's Modulus

Rsg = Resistance of Strain Gage

$$\Delta R_{sg} = (GF)(\epsilon)(120)$$

GF = gage factor

Vwb = voltage induced on Wheatstone Bridge

$$V_{wb} = (V_s/4)(GF)(\epsilon)$$

Vs = value of voltage source