Analog Computer Applications
Just for fun STEM project
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Babylonian Mathematics, Analog Computation,
and Lunar Surface Impact Speed

1 Introduction

For this project, a combination of ancient mathematics and modern electronics will be used to estimate the impact speed of an object released from rest at various heights (not to exceed 6 meters) above the surface of the moon.

On page 4, Square roots are displayed in table 1 and impact speeds are displayed in table 2.

2 Mathematical modeling

First, a brief outline of the Babylonian method to extract the non-negative square root of a number using three iterations:

Let $R^2 = N$, such that $L < N < H$, where L is the perfect square just less than N, and H is the perfect square just greater than N.

Assume that R_L is the square root of L and R_H is the square root of H, then a $R_H = R_L + 1$.

1st iteration: $R_1 = (R_L + R_H)/2 = (R_L + R_L + 1)/2 = R_L + 1/2.$

2nd iteration: $R_2 = N/R_1 = N/(R_L + 1/2).$

3rd iteration: $R_3 = (R_1 + R_2)/2 = [R_L + 1/2 + N/(R_L + 1/2)]/2.$

From elementary physics, v = √(2gh) (when drag is negligible), where g = 1.625 m/s² (value at the lunar surface) and h = N (in meters).

Simplifying, $v = \sqrt{(2 \times 1.625\ m/s^2 \times N)} \cong 1.80 \times R_3$.

3a Computer setup (patch cord version)

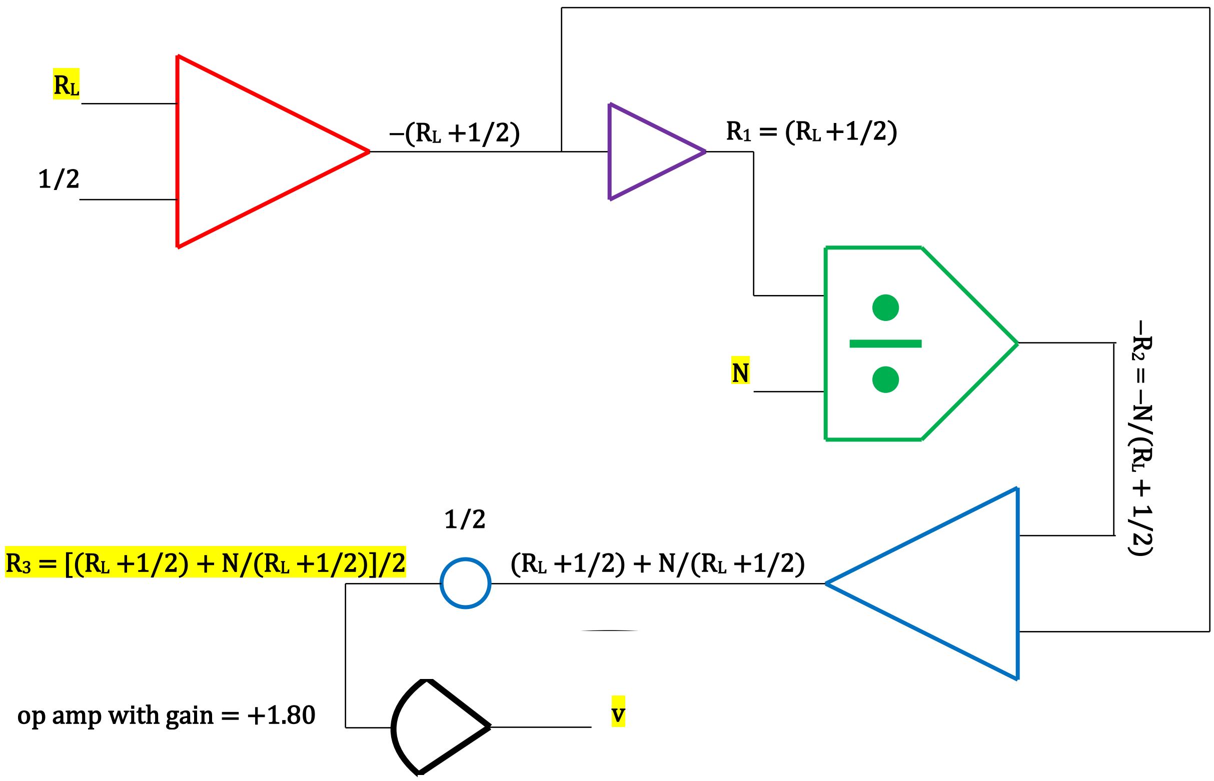

Figure 1: Computer setup

3b Computer setup (IC/discrete component version)

Arrow Color Code:

Red arrows connect to V_{CC}.
Blue arrows connect to V_{EE}.
Green arrows connect to ground.

Comments:

N is from variable DC supply.

440 k = two 220 k's in series.

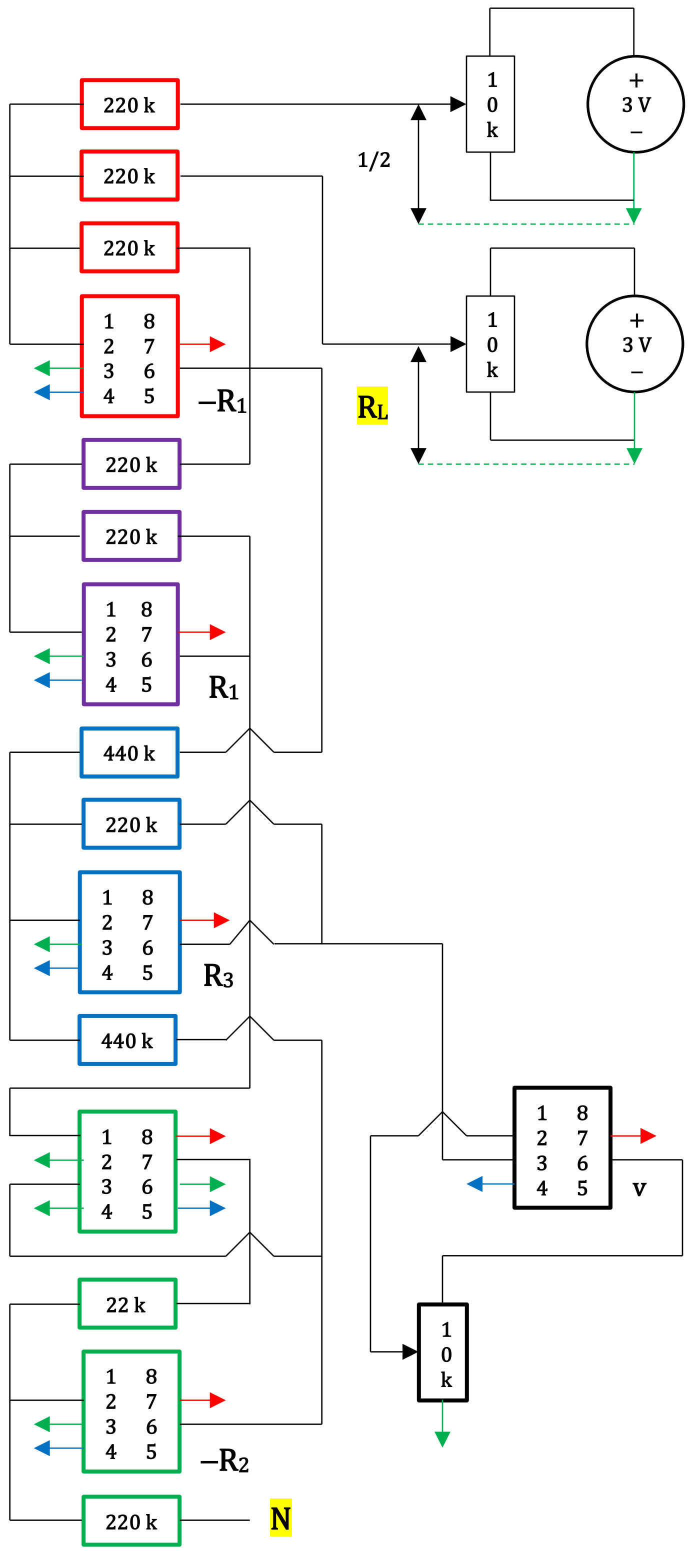

Figure 2: Basic breadboard layout

4 Results (rounded to two decimal places)

N	$R_3 \cong \sqrt{(N)}$ Babylonian method via analog computer	$R_3 \cong \sqrt{(N)}$ Babylonian method via hand-held calculator using formula	$\sqrt{(N)}$ via √ key on hand-held calculator
1.50 ($R_L = 1$)	1.26	1.25	1.22
2.50 ($R_L = 1$)	1.59	1.58	1.58
3.50 ($R_L = 1$)	1.92	1.92	1.87
4.50 ($R_L = 2$)	2.15	2.15	2.12
5.50 ($R_L =2$)	2.35	2.35	2.35
6.50 ($R_L = 2$)	2.56	2.55	2.55

Table 1: Square root comparisons

N is replaced with h (m)	Estimated v (m/s) at impact via analog computer	v (m/s) at impact via physics formula	|v difference (m/s|
1.50	2.26	2.21	0.05
2.50	2.87	2.85	0.02
3.50	3.47	3.37	0.10
4.50	3.89	3.82	0.07
5.50	4.24	4.23	0.01
6.50	4.61	4.60	0.01

Table 2: Impact speed comparisons

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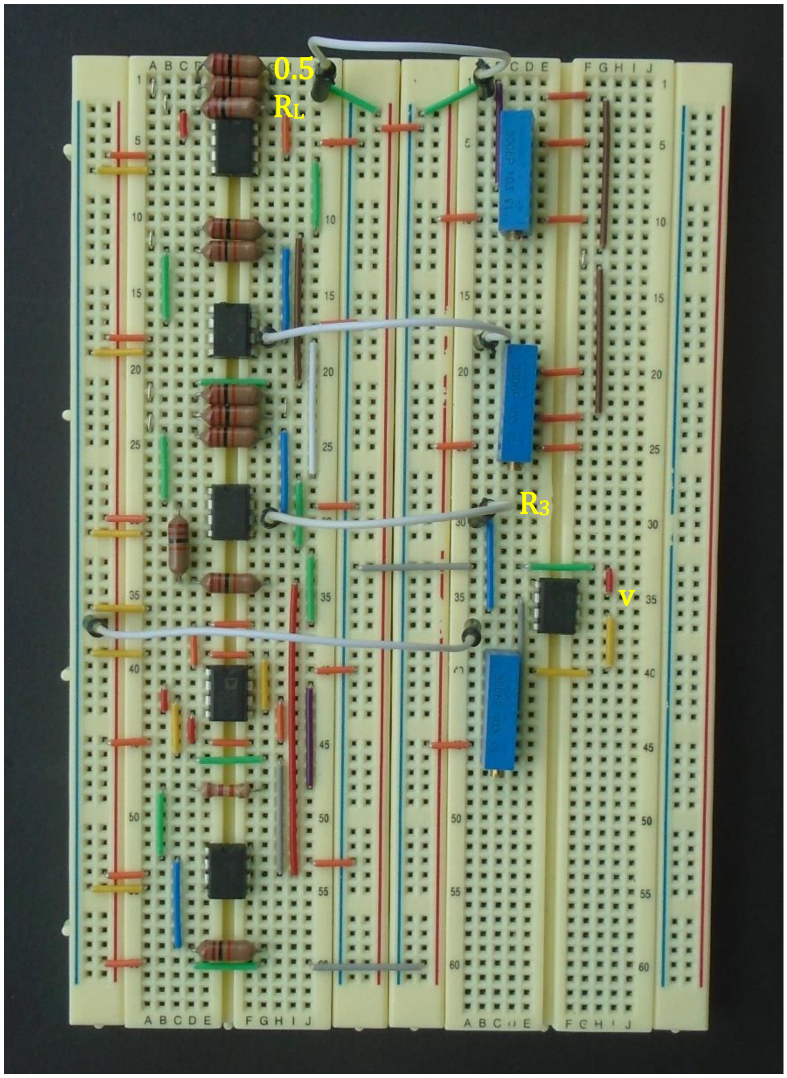

Figure 3: Basic breadboard layout (top view)

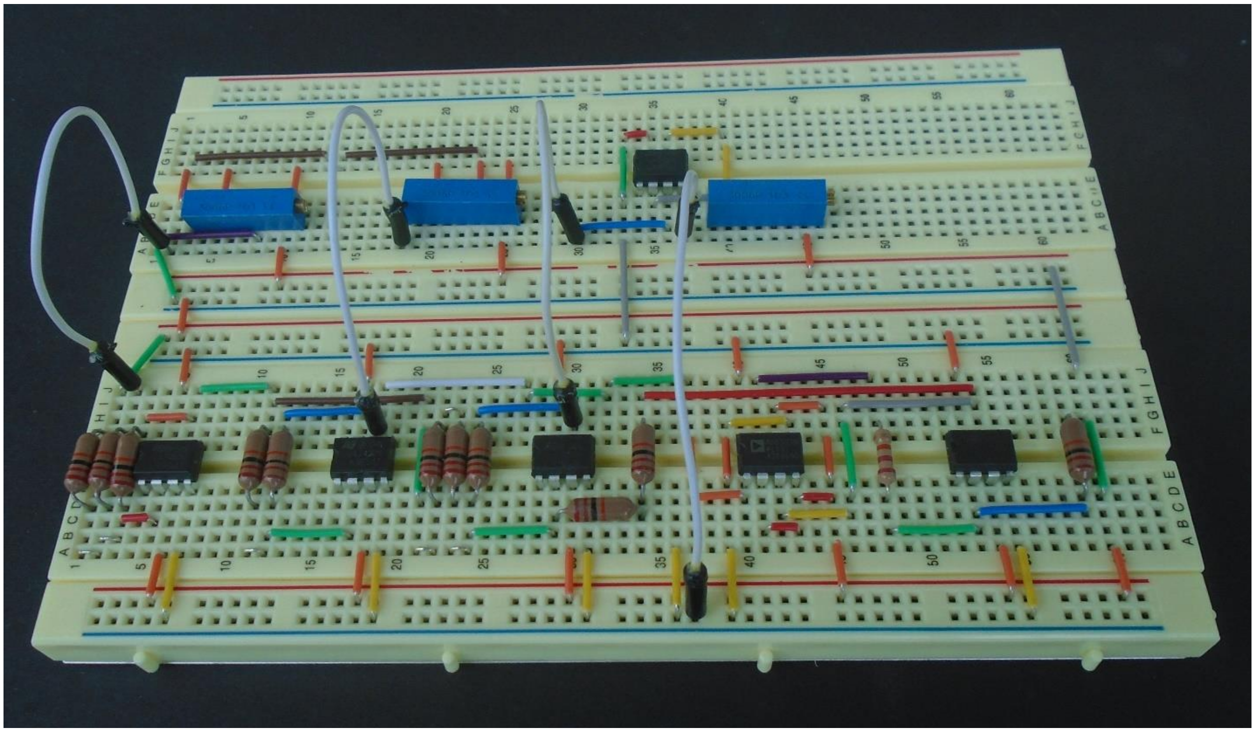

Figure 4: Basic breadboard layout (side view)