# Balancing Act

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## 1 Data Table

| Trial Number | Distance to Known Mass [$cm$] | Known Mass [$g$] |
|---|---|---|
| Trial 1 | 27 | 147.71 |
| Trial 2 | 28.6 | 145.21 |
| Trial 3 | 38.1 | 105.07 |
| Trial 4 | 32.1 | 125.13 |
| Trial 5 | 30.8 | 130.15 |
| Trial 6 | 19.6 | 205.18 |
| Trial 7 | 49.8 | 80.23 |

The rock was kept at a constant distance 30.1[$cm$] from the center of the balance.

## 2 Torque Equations

Because the balance is at equilibrium, we can assume that

$$\Sigma\tau = 0$$

Therefore, because the forces are acting on opposite sides of the meter stick, they counteract, and can be set equal to each other to find: $\tau_{rock} = \tau_{mass}$

This can be expanded to:

$$r_{rock} * F_{rock} * sin(\theta) = r_{mass} * F_{mass} * sin(\theta)$$

Because both forces are exerted at a $90^{\circ}$ angle, the sine functions can be cancelled out to yield:

$$r_{rock} * F_{rock} = r_{mass} * F_{mass}$$

Furthermore, because the forces of rock and known mass are both forces of gravity, gravitational acceleration can be cancelled in order to achieve:

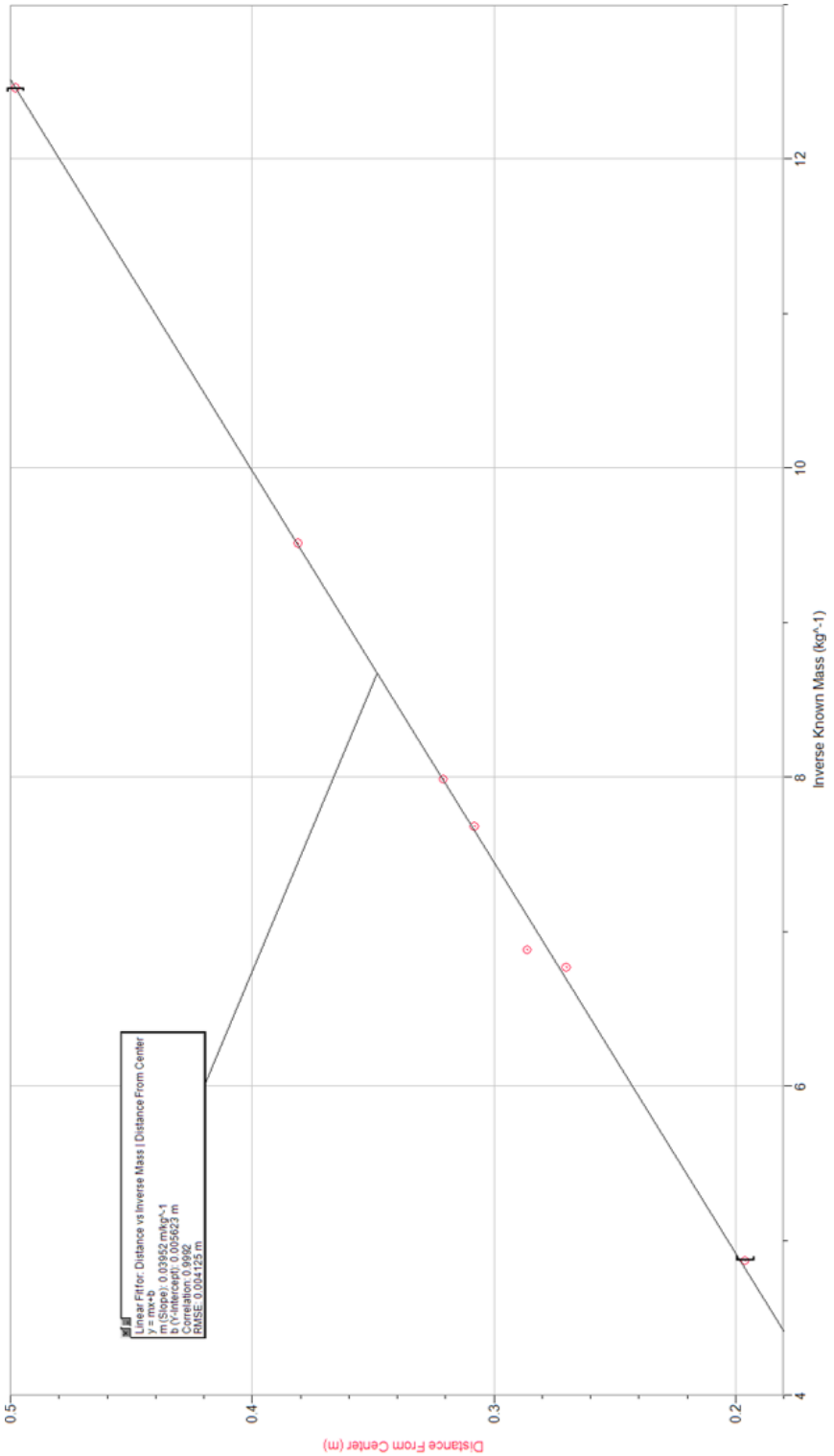
$$r_{rock} * m_{rock} = r_{mass} * m_{mass}$$

Finally, to achieve the needed form, the function can be rearranged to get:

$$r_{mass} = \frac{.301 * m_{rock}}{m_{mass}}$$

$\therefore$ The slope of the graph is equal to $.301 * m_{rock}$

# 3 Graphing


Linear Fit for: Distance vs Inverse Mass | Distance From Center
y = mx+b
m (Slope): 0.03952 m/kg^-1
b (Y-intercept): 0.005623 m
Correlation: 0.9992
RMSE: 0.004125 m
Distance From Center (m)
0.5
0.4
0.3
0.2
Inverse Known Mass (kg^-1)
4
6
8
10
12

# 4 Final Calculation

By setting the slope of the line of best fit equal to the slope function obtained earlier we get:

$$.301 * m_{rock} = .03952$$

After rearranging, we obtain the experimental value for the rock, which is:

$$m_{rock} = .1313[kg], \text{ or } 131.3[g]$$

# 5 Analysis Questions

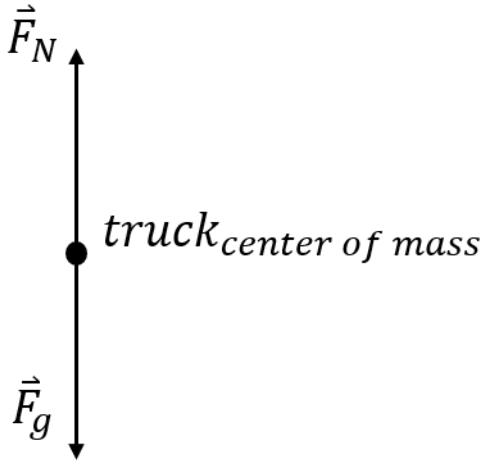
1. The actual mass of the rock is found to be: 133.06. This can then be used to find the percent error:

$$\frac{133.06 - 131.3}{133.06} * 100 = 1.323\%$$

2. The brother should sit at half the distance of the sister, so that they exert the same torque upon the seesaw, so that the seesaw balances.

3. The rope at an angle of $60^\circ$ will have a greater tension. This is because torque ($\tau$) depends on the angle, and $\sin(60^\circ) > \sin(45^\circ)$, so therefore, the rope at the $60^\circ$ angle will have a greater tension.

4. A truck moves across a bridge...




(a)

(b) The forces on Pier A are: rotational torque, the truck, the bridge itself, gravity, and the normal force.

(c) The forces on Pier B are: rotational torque, the truck, the bridge itself, gravity, and the normal force.