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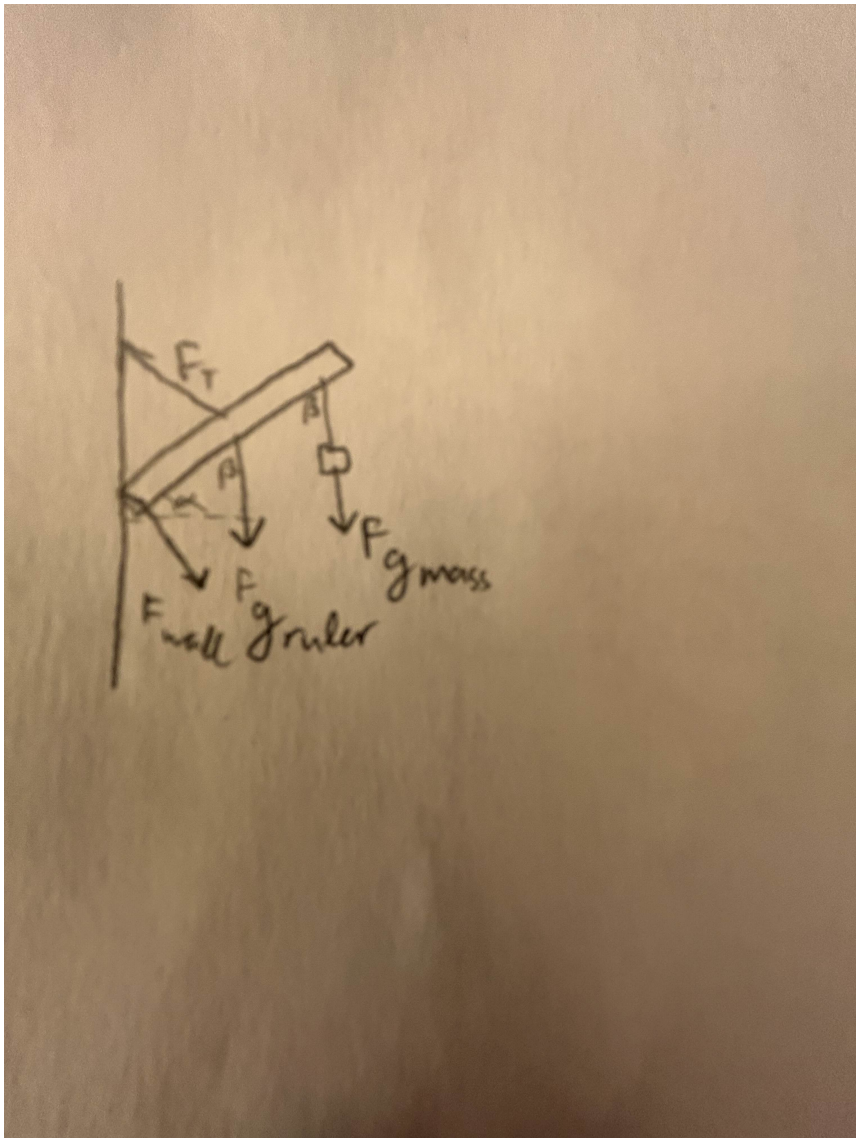
Worked with Cole TerBush and Tim Marijono

1 • Lab 1

Objective

To find the tension force required to hold up a ruler with a hanging mass.

Diagram



Derivation

$$\tau = F_T r_{string} \sin(\alpha) - F_{g_{ruler}} r_{ruler} \sin(\beta) - F_{g_{mass}} r_{mass} \sin(\beta)$$

$$F_T = \frac{\tau + F_{g_{ruler}} r_{ruler} \sin(\beta) + F_{g_{mass}} r_{mass} \sin(\beta)}{r_{string} \sin(\alpha)}$$

Since $\tau = 0$, we obtain:

$$F_T = \frac{F_{g_{ruler}} r_{ruler} \sin(\beta) + F_{g_{mass}} r_{mass} \sin(\beta)}{r_{string} \sin(\alpha)}$$

Procedures

1. Mount ruler to pole
2. Mount force sensor to pole above ruler
3. Attach force sensor to middle of ruler with string at 90° angle
4. Hang mass from end of ruler
5. Record force from force sensor
6. Repeat with mass at different lengths

Results

Constants

These values were constant throughout the experiment.

Ruler Mass (kg)	String r (m)	Alpha (deg)	Beta (deg)
$7.2 \cdot 10^{-2}$	0.25	90	65

Experimental Results

Mass (kg)	Mass r (m)	Theoretical Tension Force (N)	Measured Tension Force (N)
1	0.4	14.85	16.57
1	0.3	11.3	12.6
1	0.2	7.74	8.59
1	0.1	4.19	4.66
0.5	0.4	7.74	8.39
0.5	0.3	5.97	6.42
0.5	0.2	4.19	4.46
0.5	0.1	2.42	2.56

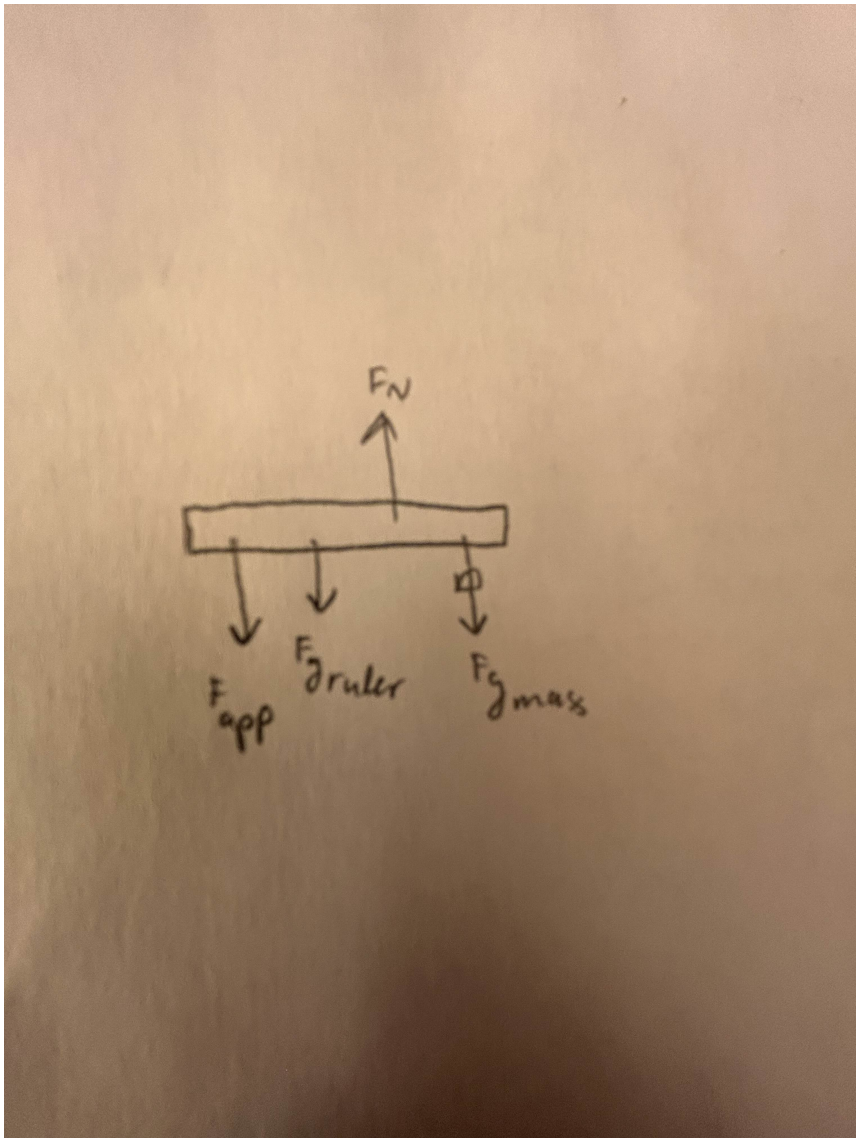
Overall, our measured tension forces were fairly close to our calculated tension forces.

2 • Lab 2

Objective

To find the force required to balance a fulcrum with a hanging mass.

Diagram



Derivation

$$\tau = F_{app}r_{app} + F_N + F_{g_{ruler}}r_{ruler} + F_{g_{mass}}r_{mass}$$

$$F_{app} = \frac{\tau - F_N - F_{g_{ruler}} r_{ruler} - F_{g_{mass}} r_{mass}}{r_{app}}$$

Since $\tau = 0$ and $F_N = 0$ because $r_N = 0$, we obtain:

$$F_{app} = \frac{-F_{g_{ruler}} r_{ruler} - F_{g_{mass}} r_{mass}}{r_{app}}$$

Procedures

1. Place ruler on force sensor
2. Hang mass from one end
3. Press down on other end with second force sensor
4. Record force from second force sensor
5. Repeat with different positions on ruler as fulcrum

Results

The sign of r was adjusted depending on if the force applied caused a positive (counterclockwise) rotation or negative (clockwise) rotation.

Constants

These values were constant throughout the experiment.

Ruler Mass (kg)	Mass Position (m)
$7.2 \cdot 10^{-2}$	0.42

Experimental Results

Mass r (cm)	Normal Force (N)	Theoretical Balancing Force (N)	Measured Balancing Force (N)	Fulcrum Posit
$-7 \cdot 10^{-2}$	12.28	3.08	1.83	0.35
-0.12	14.26	7.84	3.79	0.3
-0.17	17.6	11.11	7.12	0.25
-0.22	22.65	14.37	12.25	0.2

Overall, our measured tension forces were lower than our calculated tension forces.