Input handler 1

Concept: Buoyancy of balloon lifts lever, dropping ball into chute, where it rolls into a trap and presses a button.

$F_{b_{net}} \leq 0.09\,N$ (from handler 1 calcs) – require about half, $0.03N \leq F_{b_{min}} \leq 0.06N$

F_g (ball) + F_g(cup) > 0.5N (to depress a very light switch, e.g. Cherry Red @ 50g)

Assume ball alone should activate $F_g(ball) > 0.5N$

$F_g(BC) = \rho a |BC|$ $\quad F_g(AB) = \rho a |AB|$ $\quad$ a = cross-sectional area of lever

Conditions where lever requires at least 0.03N and at most 0.06N applied at A to move:

$-\vec{M}_B(0.03N) \leq \sum \vec{M}_g \leq -\vec{M}_B(0.06N)$

$0.03N|AB|\cancel{\cos\theta} \leq \frac{\rho a|AB| \times |AB|\cancel{\cos\theta}}{2} - \frac{\rho a|BC| \times |BC|\cancel{\cos\theta}}{2} - 0.5N|BC|\cancel{\cos\theta} \leq 0.06N|AB|\cancel{\cos\theta}$

Let $r = |AB|$, $s = |BC|$

$0.03r \leq \frac{\rho a}{2} r^2 - \frac{\rho a s^2}{2} - 0.5s \leq 0.06r$

$0.06r \leq \rho a(r^2 - s^2) - 0.5s \leq 0.12r$

Assume lever is 3D printed PLA at about 30% average fill (incl. walls)

Then $s + r \leq 250mm$ – assume max length, then $r^2 - s^2 = 0.25m(r-s)$

$\rho = 0.3(1200\,kg/m^3)$

$= 360\,kg/m^3 \times 9.8\,m/s^2$

$= 3528\,N/m^3$

Assume a chunky bar for good rigidity, $a = 40mm \times 40mm = 0.0016m^2$

$\rho a = 3528 \times 0.0016 = 5.65\,N/m$

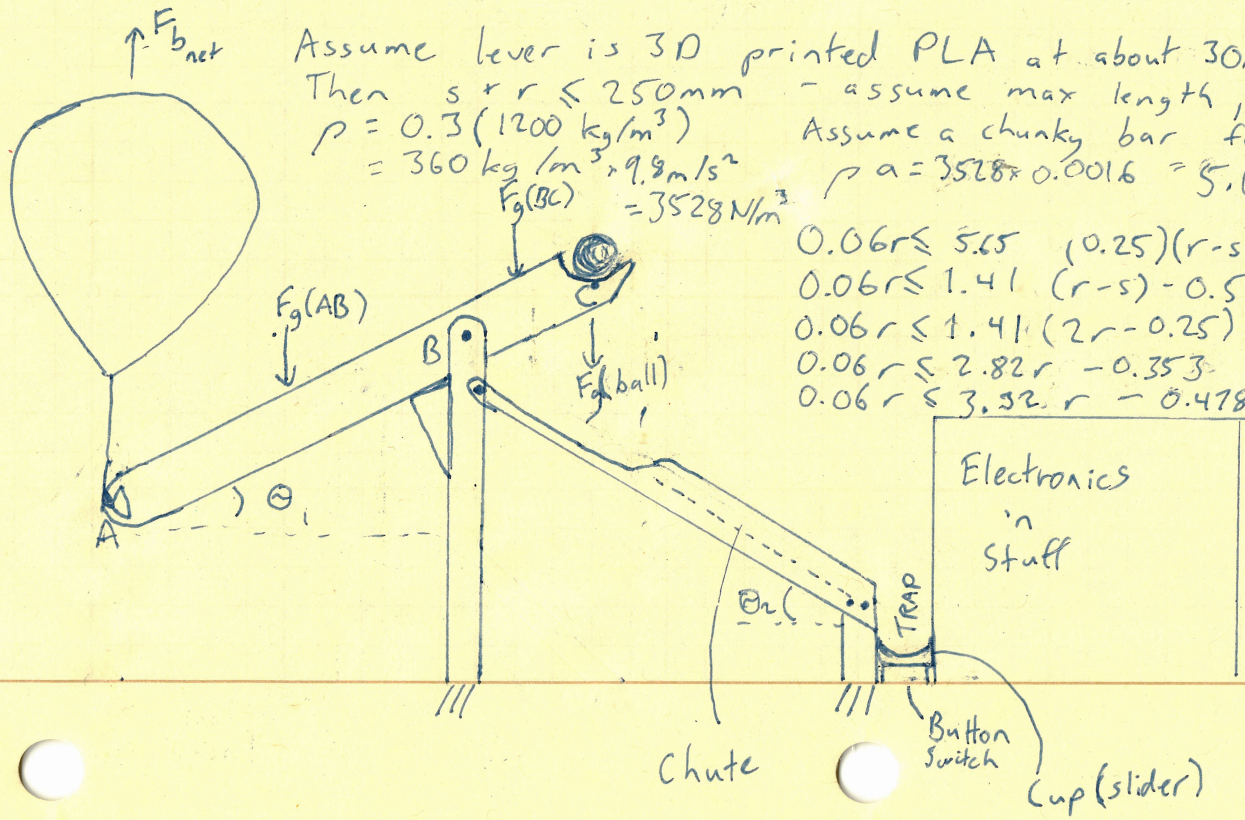
$0.06r \leq 5.65(0.25)(r-s) - 0.5s \leq 0.12r$

$0.06r \leq 1.41(r-s) - 0.5s \leq 0.12r$ $\qquad s = 0.25 - r$

$0.06r \leq 1.41(2r - 0.25) - 0.5(0.25 - r) \leq 0.12r$

$0.06r \leq 2.82r - 0.353 - 0.125 + 0.5r \leq 0.12r$

$0.06r \leq 3.32r - 0.478 \leq 0.12r$



$3.32r - 0.478 \leq 0.12r$

$3.2r \leq 0.478$

$r \leq 0.149\,m$

$3.32r - 0.478 \geq 0.06r$

$3.26r \geq 0.478$

$r \geq 0.146\,m$

Input Handler I Preliminary Values

$\lvert AC \rvert = 250\,mm$	Total lever length
$\lvert AB \rvert = 148\,mm \pm 1mm$	Lever arm, balloon side
$\lvert BC \rvert = 102\,mm \pm 1mm$	Lever arm, ball side

$W_{ball} = 0.5N$

$m_{ball} = 51\,g$

$W_{cup} < 0.5N$

$\rho(lever) = 5.65\ N/m$ — Linear density of lever

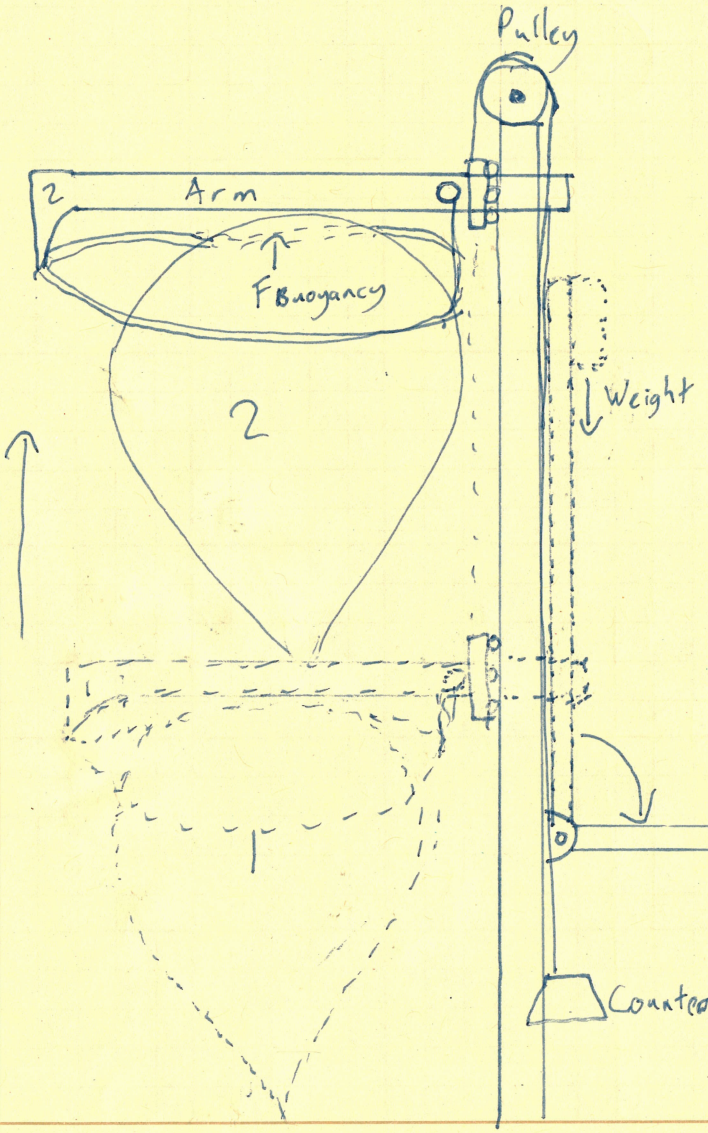
θ_1: unconstrained — Lever starting angle

θ_2: >0 — Ramp angle

Input Handler 2

<u>Concept</u>: Retaining arms hold lever against pillar until balloon lifts arm a sufficient distance

Counterweight balances arm + static friction − $F_{Buoyancy_{min}}$



$$F_{buoyancy} = \frac{4}{3}\pi r^3 (\rho_{air} - \rho_{gas})$$

Assuming gas is helium and $r = 0.5$ ft,

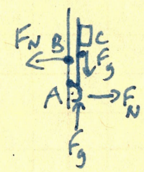
$$F_b = \frac{4}{3}\pi (0.5ft)^3 (0.0114 - 0.0807) \, lb/ft^3$$

$$F_b = 0.03611 \, lb = 0.161 \, N = 16.4 \, g_{force}$$

m balloon $\approx 7g$, so $F_{b_{net}} \approx 0.0921N = 0.0207$ lb

$$F_f = \mu_f F_N$$

Assume linear bearings, $\mu_f \approx 0.003$

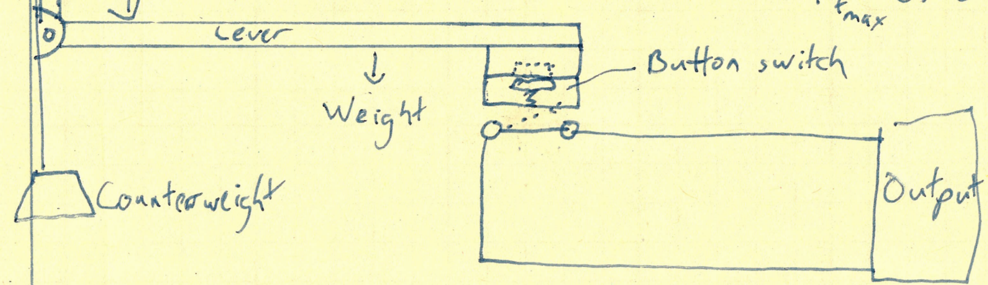


$$\overset{\curvearrowright}{M_A} = 0 \qquad F_g(\overline{AC_x}) = F_N(\overline{AB})$$

$$F_{N_{max}} = F_g(\overline{AC_x}) / \overline{AB}_{min}$$

$$F_{f_{max}} = 0.003 \, F_g(\overline{AC_x}) / \overline{AB}_{min}$$

where F_g is weight of the lever, AC_x is the horizontal distance to the center of gravity of the vertical lever, and AB_{min} is the starting distance between retaining arm and pivot point



Input Handler 2 (continued)

$F_{buoyancy\,net} \approx 0.09\text{ N}$ - require about half, $0.03\text{N} \leq F_{b\,min} \leq 0.06\text{N}$

$$F_{g\,counterweight} = F_{g\,arm} + 0.003\, F_{g\,weight}\left(\frac{\overline{AC_x}}{\overline{AB_{min}}}\right) - F_{b\,min}$$

Assume the arm has a linear density of 5.65 N/m (see input handler 1) and a length of 0.25 m. Then $F_{g\,arm} = 1.41\text{ N}$

Assume the weight is 0.5N to trigger the same switch as in handler 1
Assume the sliders/bearings have equal weight on each side
Start the sliding action at least 20 mm from the pivot point: $\overline{AB}_{min} = 0.02\text{m}$
Set the center of mass of the weight 40mm from the pillar: $\overline{AC_x} = 0.04\text{ m}$

Then $1.41\text{ N} + 0.003(0.5\text{N})\left(\frac{0.04}{0.02}\right) - 0.06\text{ N} \leq F_{g\,cw} \leq 1.41 + 0.003(0.5)\left(\frac{0.04}{0.02}\right) - 0.03$
$1.353\text{N} \leq F_{g\,cw} \leq 1.383\text{ N}$

Preliminary values - Input Handler 2

$\lvert Arm \rvert$	$= 0.25\text{m}$	Length of arm holding balloon
$F_{g\,weight}$	$= 0.5\text{ N}$	Weight at end of lever
$F_{g\,arm}$	$= 1.41\text{ N}$	Weight of arm
$F_{g\,counterweight}$	$= 1.37\text{ N} \pm 0.01\text{ N}$	Weight of counterweight
$\lvert AB_{min} \rvert$	$= 0.02\text{m}$	Distance from pivot point to retaining arm start point
$\lvert AC_x \rvert$	$= 0.04\text{m}$	Distance from pivot point to center mass of lever weight

Output Design A: Rack and Pinion

Gear ratio calculation:

Assume 1400 KV high-torque RC motor + ESC, 3S LiPo @ 11.1V nominal
Max RPM: 15,540 (no load)
RPM under light load: ~ 10,000 max? (around 60%)

Goal: move rack 120mm in about 4 seconds (30 mm/s)
Assume gear m = 1, p = 3.14
$30\,\text{mm/s} \times \dfrac{1\ \text{tooth}}{3.14\ \text{mm}} = 9.55\ \text{teeth/s}$
Small pinion at 14T needs 0.68 rev/s = 41 rpm

If motor pinion is also 14T
and spur is 56T (4:1)
reduced to 14T (4:1)
then I can run the motor at
656 RPM (about 7% of max?)
That seems low. Let's put
a planetary gearbox on the
motor for another 4:1 —
that lets me run at 2624 RPM.