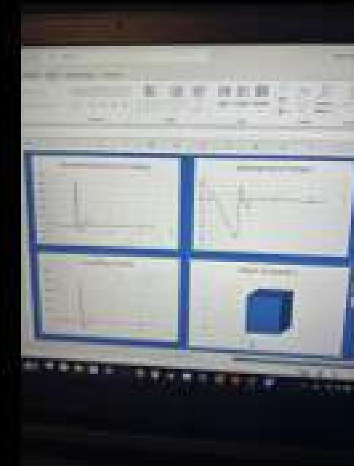
Table 3's Drop Test Apparatus

In-Person Presenters: Neil, Mayan, Jonathan

Design by: Mayan Rosales, Jonathan Thibodeaux, Daniel Wright, Dvir Ramgarib, Matthew Rohde, Neil Muralles

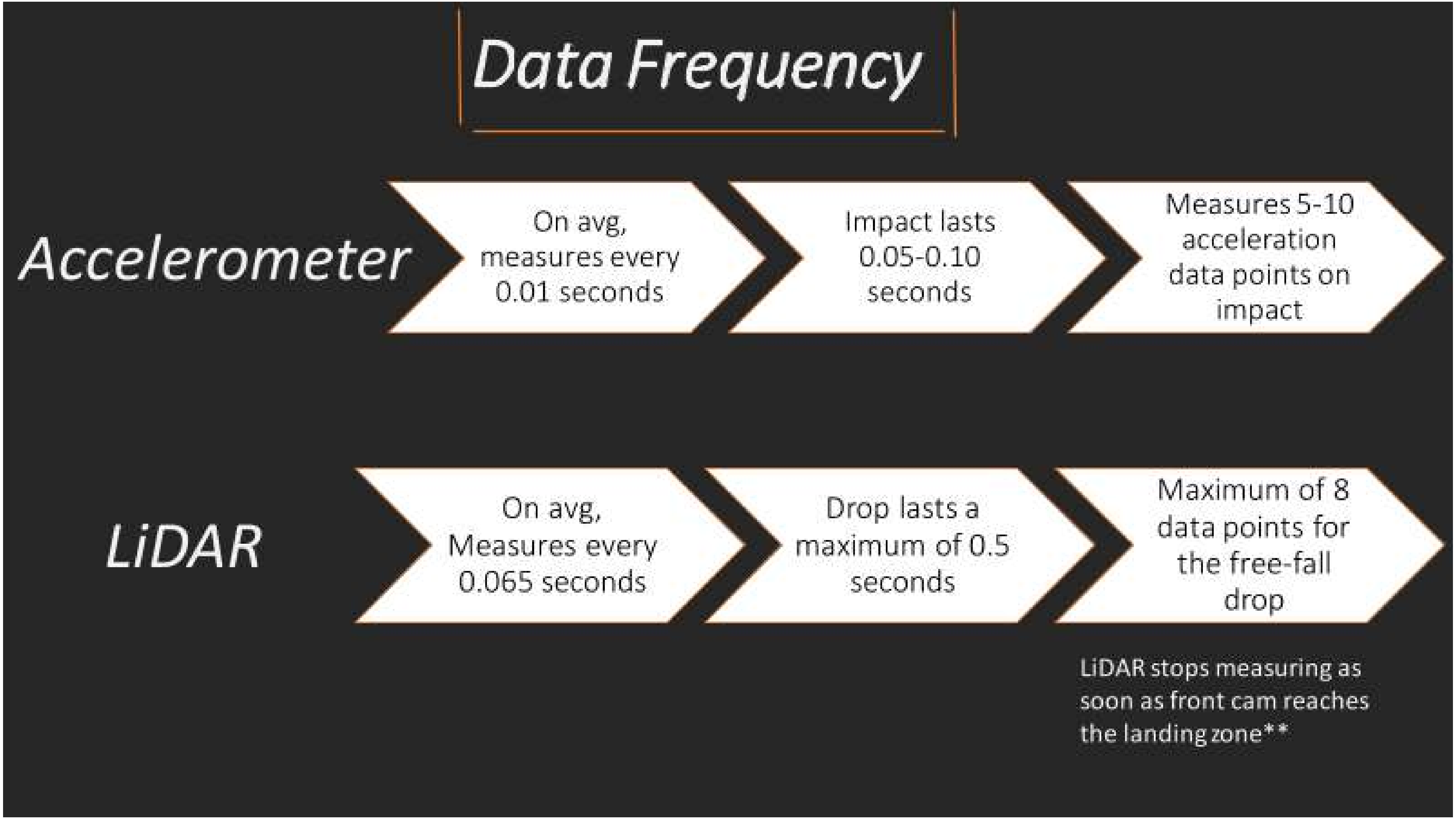


What the *Customer* asked for…

- More data points in a measurement pulse rather than less
- Matching peak magnitudes between similar tests
- Reduced level of ‘noise’ in the data
- Ease of use, novice user can perform experiments correctly
- Data for acceleration, velocity, displacement, and force

PhyPhox

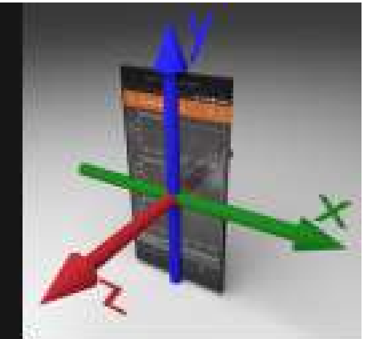
- Phyphox allows the use of internal sensors within a phone to perform multiple experiments with different metrics measured
- Provides different approaches to obtain the customer's requested data types of Acceleration, Velocity, Displacement, and Force
- Can be installed on any modern iPhone or Android device


Data Frequency
Accelerometer
On avg, measures every 0.01 seconds
Impact lasts 0.05-0.10 seconds
Measures 5-10 acceleration data points on impact
LiDAR
On avg, Measures every 0.065 seconds
Drop lasts a maximum of 0.5 seconds
Maximum of 8 data points for the free-fall drop
LiDAR stops measuring as soon as front cam reaches the landing zone**

Peak Magnitudes

- ✓ Incremental Markers
  - By marking the post every 8 inches, the user will easily be able to identify points in order to repeat tests at similar heights
- ✓ Durable Landing Zone
  - With a durable landing zone, there will be little to no deformation. This allows the drops at similar heights to all experience the same level of impact absorption

Noise Reduction

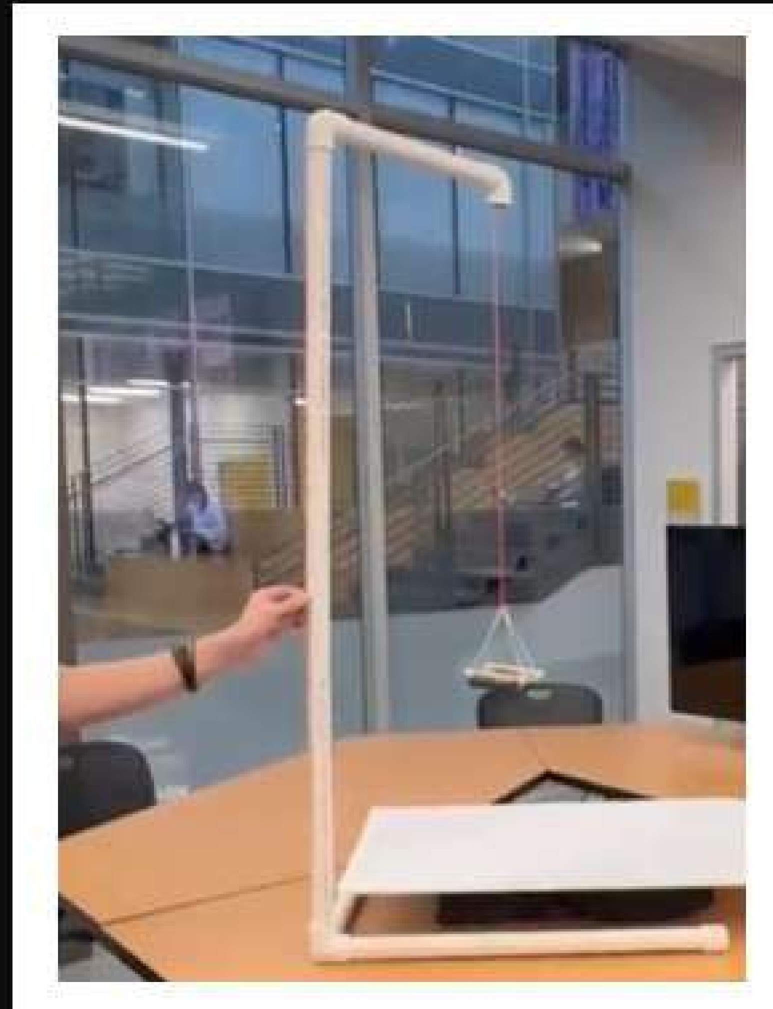


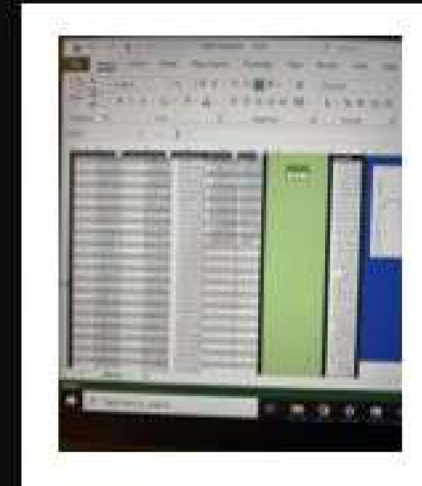
- ✓ Hung By a String
  - With the phone being hung by the string and oriented horizontally, the sensors will pick up data from the axis of interest (z axis) with little interference from the other two axes
- ✓ Flat Landing Zone
  - Having a level, flat landing zone will prevent the phone from rotating and effecting the acceleration data on the z-axis

Ease-of-Use

To meet customer requests, we designed our apparatus and our method to be simple and straightforward.

- Set up remote access with phyphox (~2 minutes to learn)
- Lift up the phone and drop (~1 minute to learn)
- Export data and enter it into the excel interface (~3 minutes to learn)





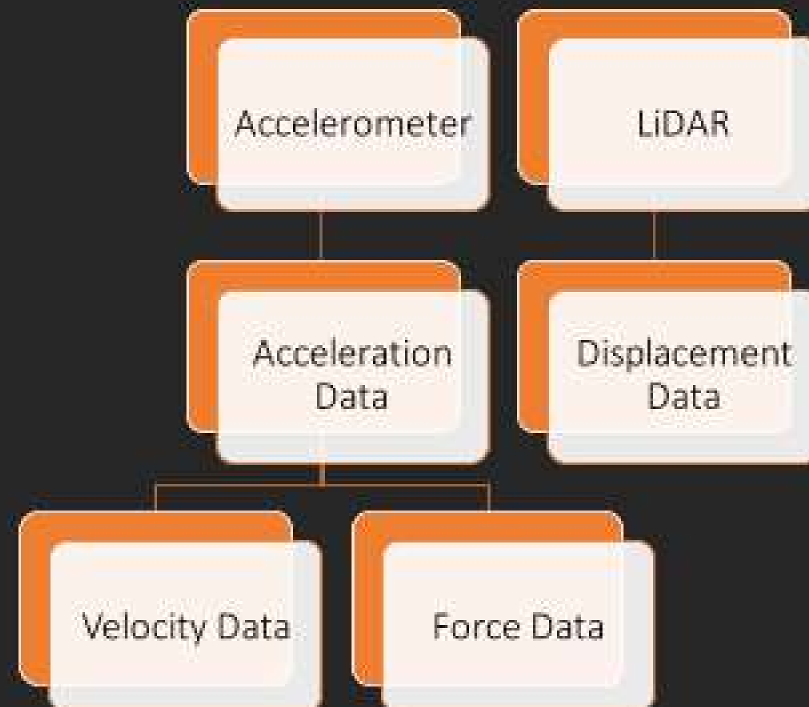
Data Collection Method – LiNA (LiDAR and Accelerometer)

Acceleration(m/s/s) – Obtained directly from the accelerometer(without g)

Velocity(m/s) – Found by integrating the acceleration data within phyphox

Displacement(m) - Obtained directly from the LiDAR depth sensor

Force(N) - Using F = m x a, force is found by multiplying the mass of the dropped object, the phone, by the acceleration data

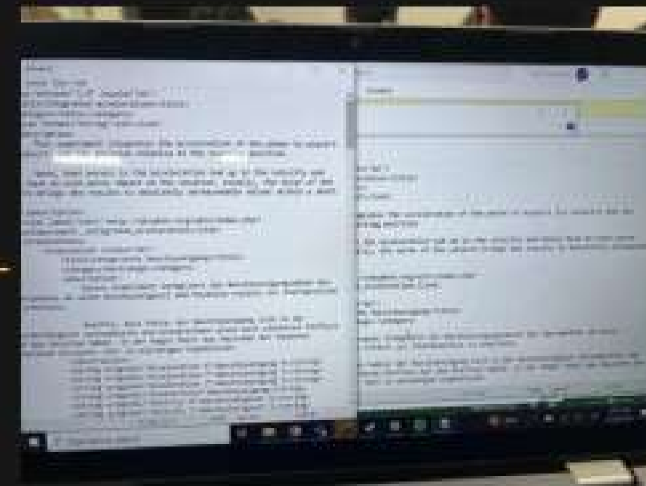


Notes:

- LiDAR on a phone uses the front camera to send out invisible pulses of light which reflect off of surfaces back to the camera. Distance is determined by how long it takes for the light to return back to the camera
- Phyphox integration methods works by multiplying the difference between times of measurement by the measured acceleration

Iterations

By far, the most iterated design feature was the method in which to collect our four data types



When determining which test to use, we noticed two things:

1. Accelerometer was very *GOOD* at measuring acceleration
2. LiDAR Depth Sensor was very *GOOD* at measuring distance to landing zone

What does "*GOOD*" mean?

- For the accelerometer(without g), when testing the acceleration during free fall, the values averaged out around 9.81m/s/s
- For the LiDAR Depth Sensor, when measuring objects at distances set apart by a measuring tape, it measured distances highly accurately compared to the measuring tape

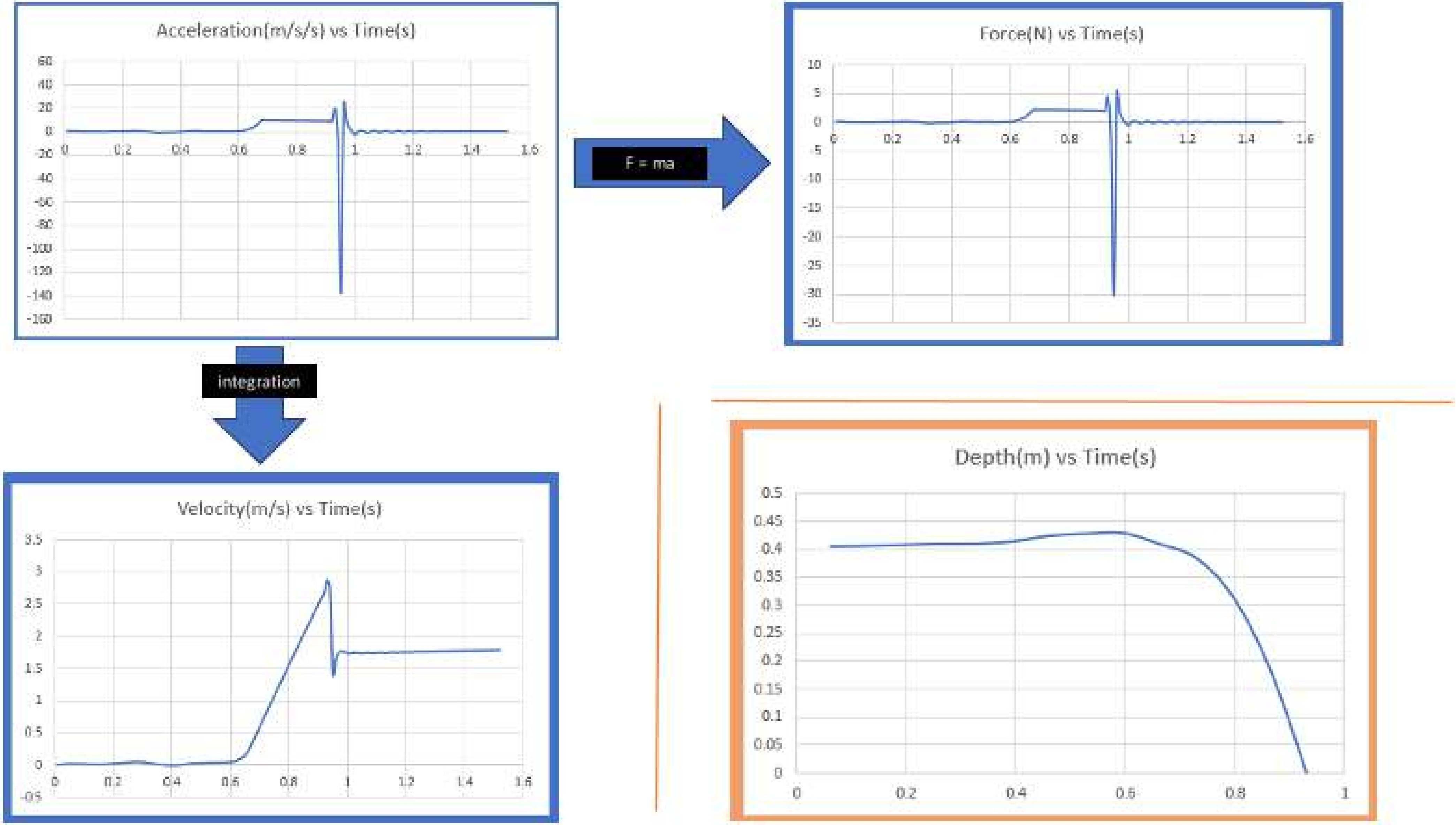
How to obtain Force and Velocity?

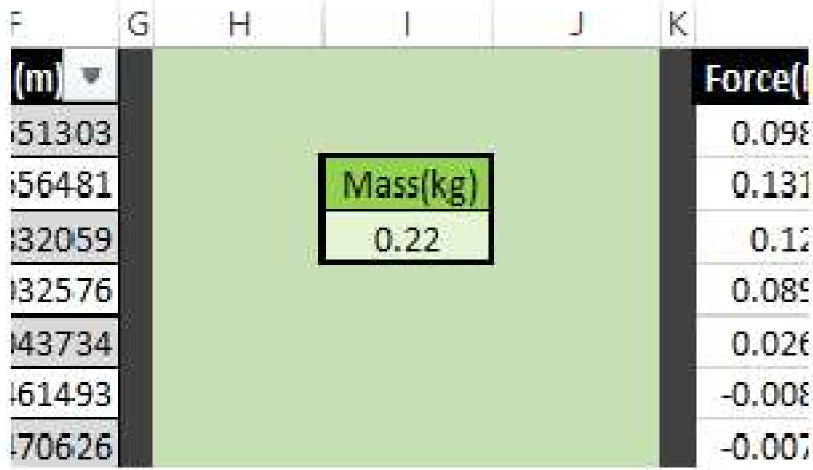
- ✓ Force can be obtained simply by multiplying the acceleration data by the mass of the phone in kilograms
- ✓ Velocity can be obtained by using phyphox's built in integration to integrate the acceleration data

Combining Accelerometer and LiDAR

- Needed to access raw xml format of phyphox tests and manually take parts from both the accelerometer test and LiDAR test to create our own combination of these tests

Graphs

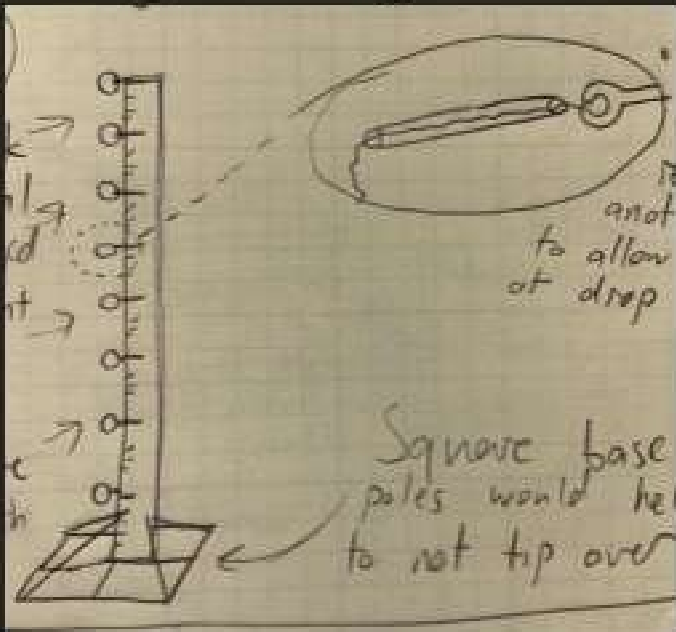

Acceleration(m/s/s) vs Time(s)
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
F = ma
Force(N) vs Time(s)
10
5
0
-5
-10
-15
-20
-25
-30
-35
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
integration
Velocity(m/s) vs Time(s)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Depth(m) vs Time(s)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.2
0.4
0.6
0.8
1

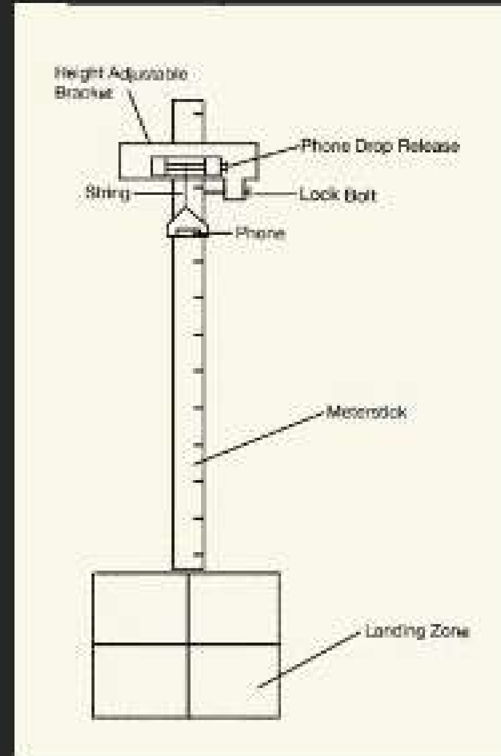


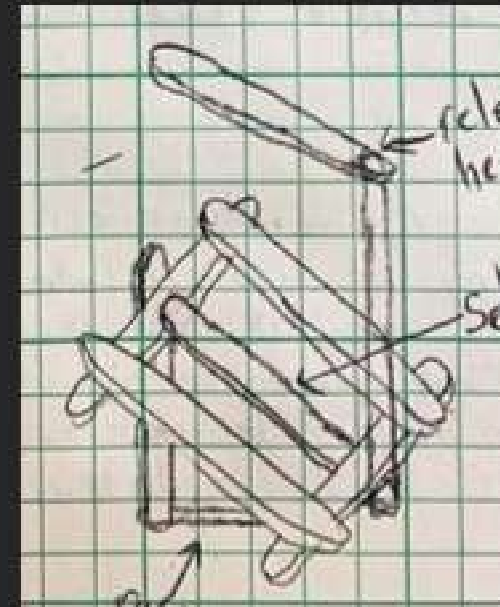
Note that...

User will input the mass in kilograms of the object before performing test

Early Designs





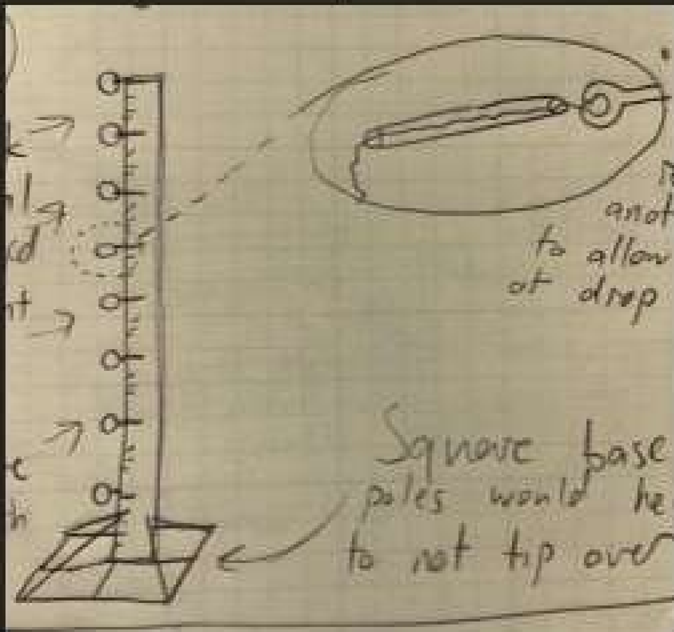


-Metal rings at set distances on a meterstick
-Straw with string fed through
-base made of popsicle sticks and foam board base

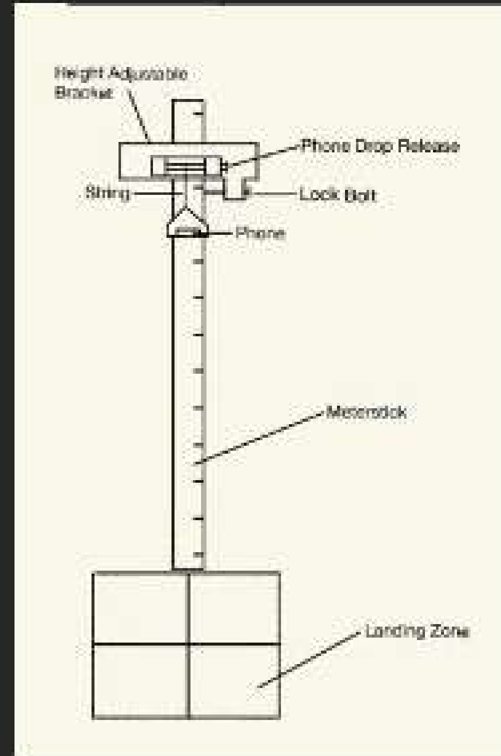
-Adjustable bracket connected to meterstick
-Landing zone underneath to protect phone

-Popsicle stick release system, rubber band holds phone and drops by releasing the rubber band

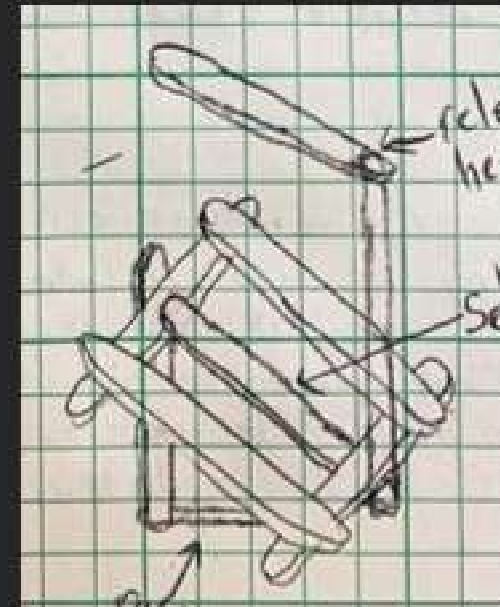
Takeaways:



pro: changeable drop heights
con: set distances wouldn't allow for full customizability



pro: Height can be changed to any level
con: Bracket would likely be too expensive compared to other methods



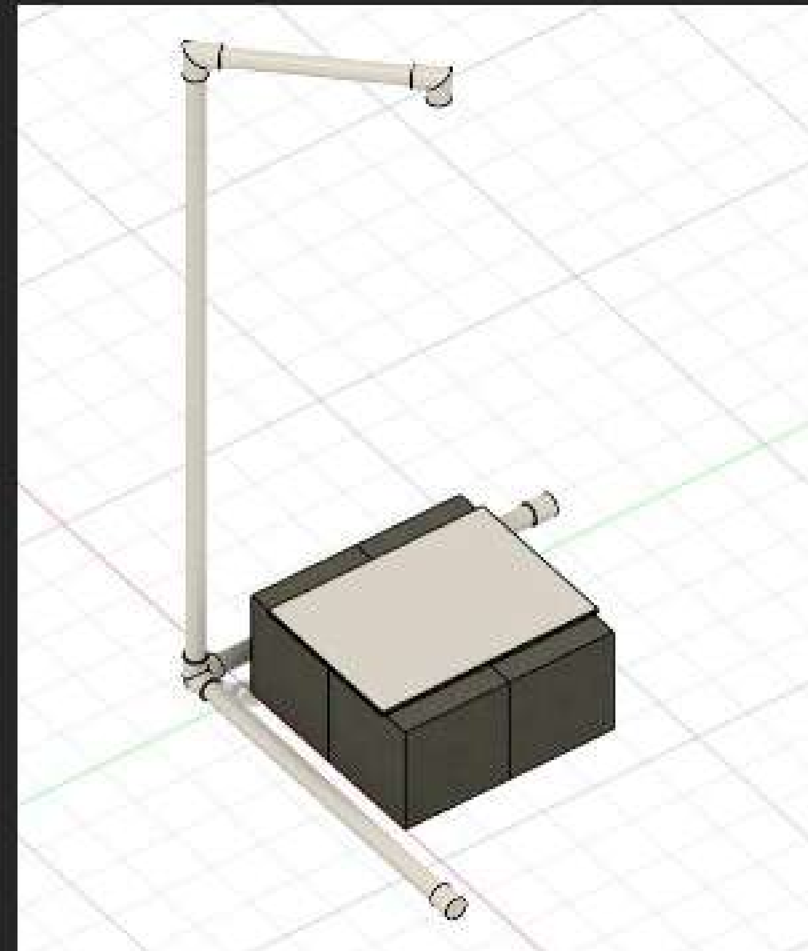
pro: easy tension release system
con: Popsicle sticks might not be as durable as other options

Final Design

- Made with 1 inch PVC piping
- Two legs support the post and head
- String fed through the back and out the front
- Phone attached to the end of the string using a popsicle stick cage
- Landing zone made of four cubes and two foam boards
- Can be lifted to any height between the landing zone and the top

Fusion360 Model

Components by Daniel
Assembly by Daniel & Neil

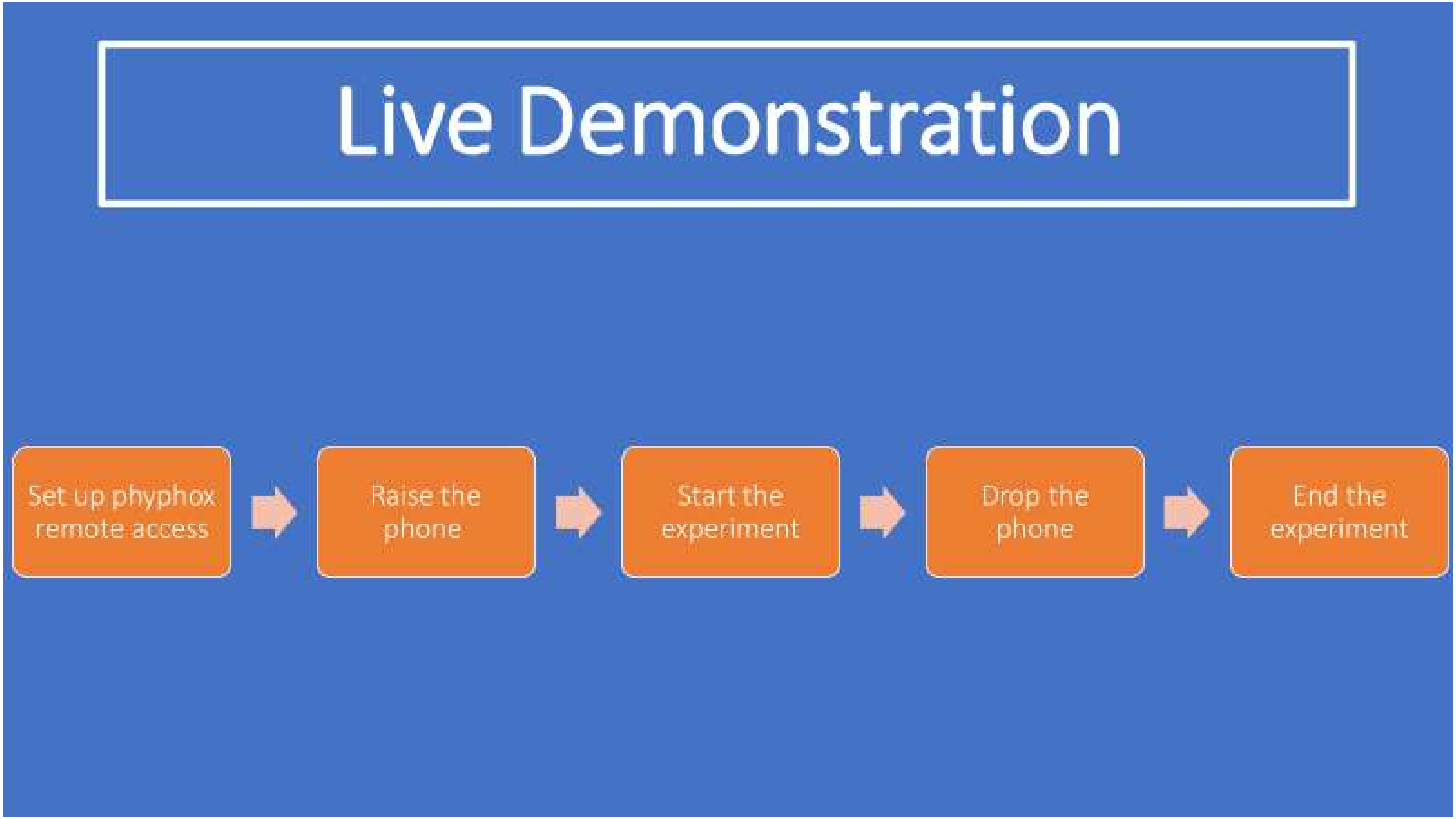


Bill of Materials (BOM)

Apparatus

Name	Quantity	Cost per one	Total
10ft of 1" PVC	1	$8.06	$8.06
1" PVC Endcap	2	$1.17	$2.34
1" PVC 90^0 Elbow	2	$1.48	$2.96
1" PVC Triple Elbow	1	$5.22	$5.22
Orange String	1	$3.97	$3.97
Foam Board	2	$1.00	$2.00
Foam Cube	4	$3.90	$15.60
Small Binder Clip	1	$0.41	$0.41
Popsicle Stick	4	$0.03	$0.12
Rubber Band	11	$0.02	$0.22

Total: $40.90


Live Demonstration
Set up phyphox remote access
Raise the phone
Start the experiment
Drop the phone
End the experiment