



 Python Main Start  
Initialize Controller

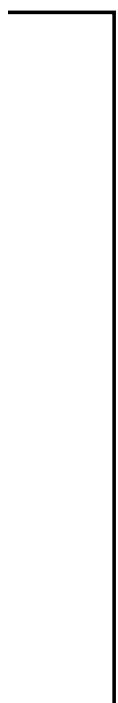
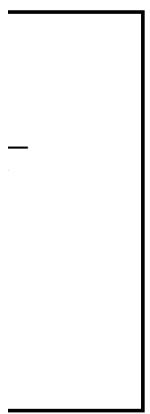
 Initialization Phase

- Create SurfaceTensionController
  - Load test profiles 1-8
  - Detect serial port
  - Connect to Arduino
  - Create output directory
  - Load calibration from EEPROM

 Serial Connection

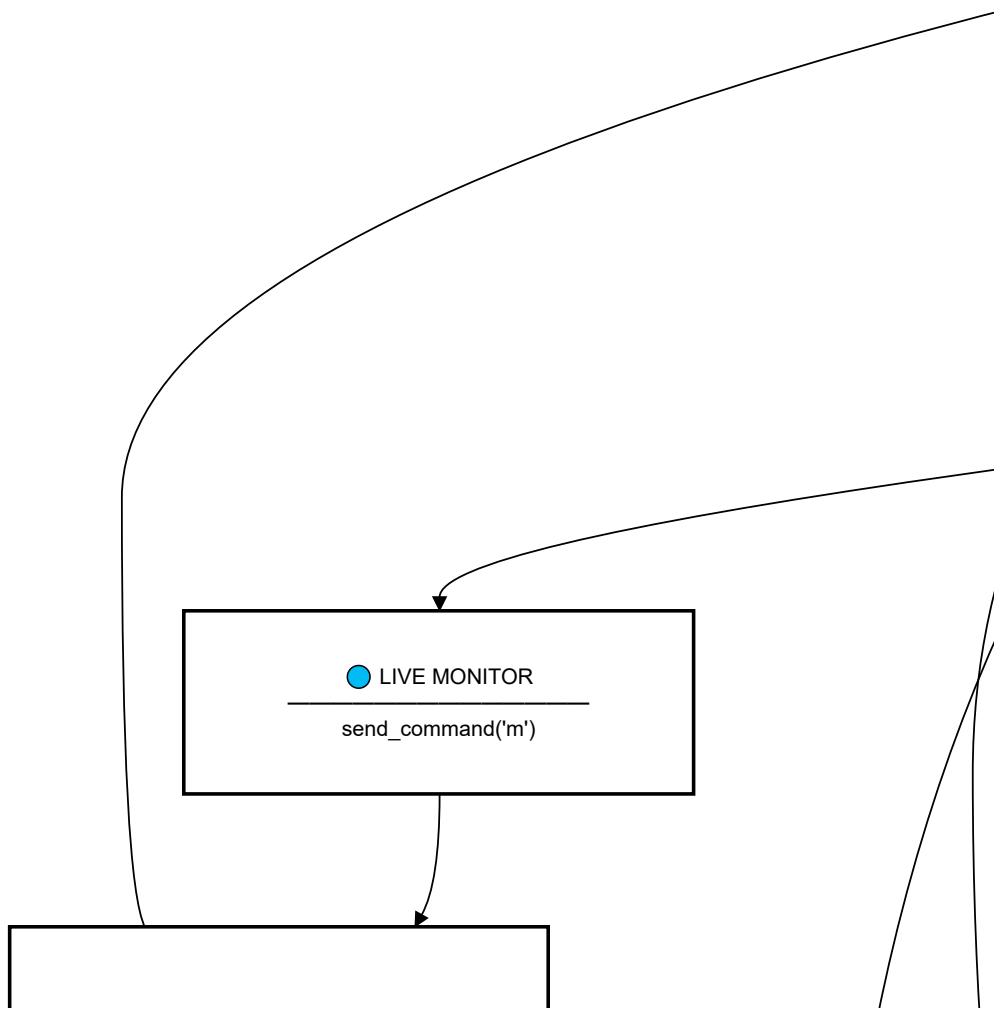
connect\_serial()

- 1 Try connect port (auto-detect: COM5)
- 2 Set baudrate: 115200
- 3 Wait 2 seconds (Arduino hardware reset)
- 4 Check connection if success: continue else: list\_ports()









 Wait for Arduino Init

Read ~3 seconds  
Looking for:  
'System Ready'  
'✓ Ready!'  
messages

 Display Main Menu

show\_menu()

Display options:  
M - Live Monitor  
1-8 - Test Speed  
A - Auto Sequence  
C - Calibration  
T - Tare  
0 - Set Home  
H - Go Home  
Q - Quit  
S - Save & Exit

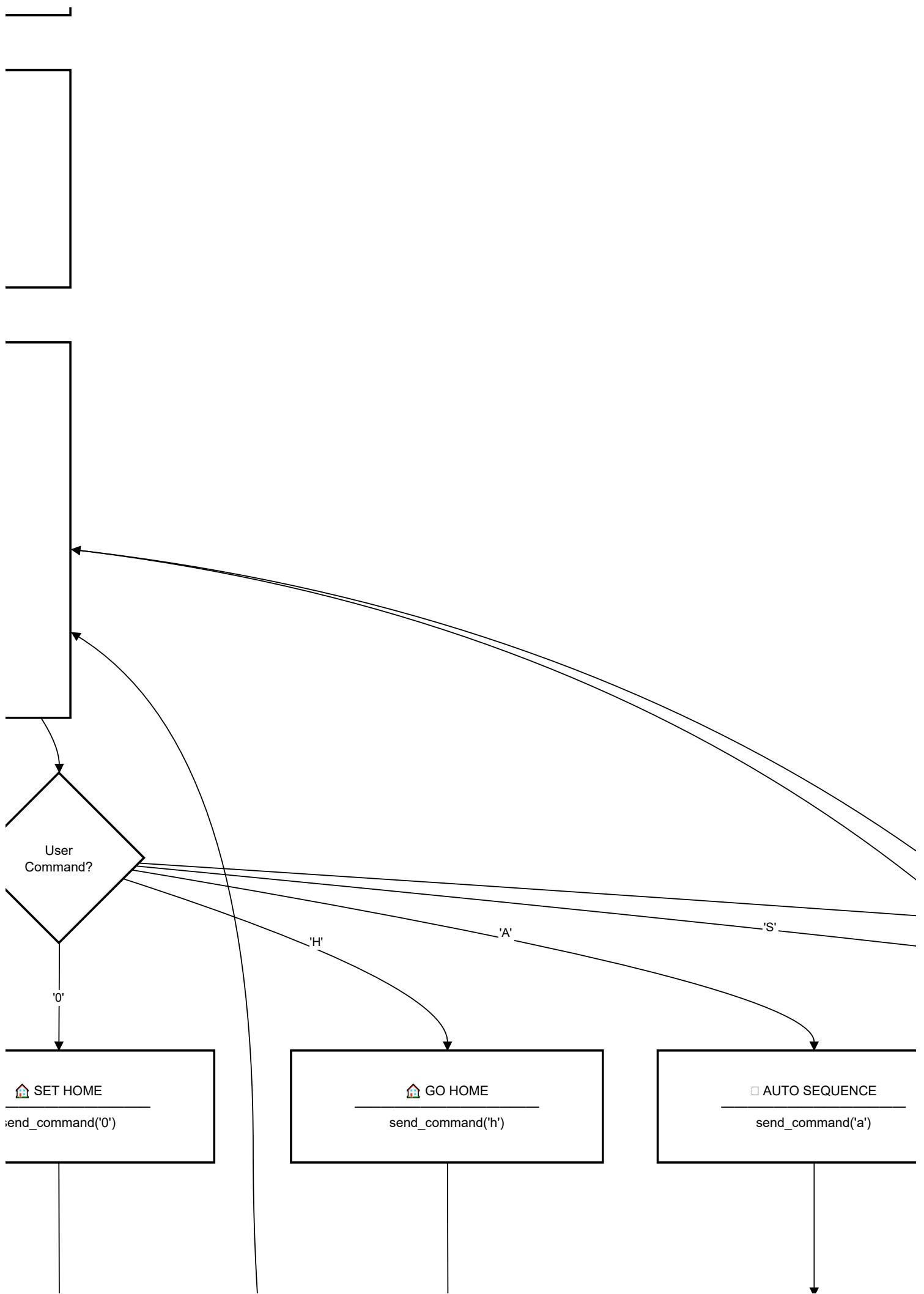
 TARE COMMAND

send\_command('t')

 CALIBRATION

send\_command('c')

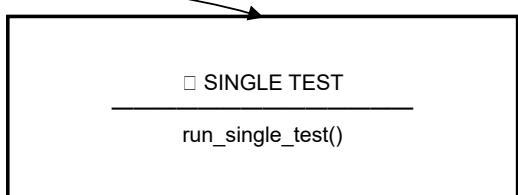
s



'1-8'

 Save & Display

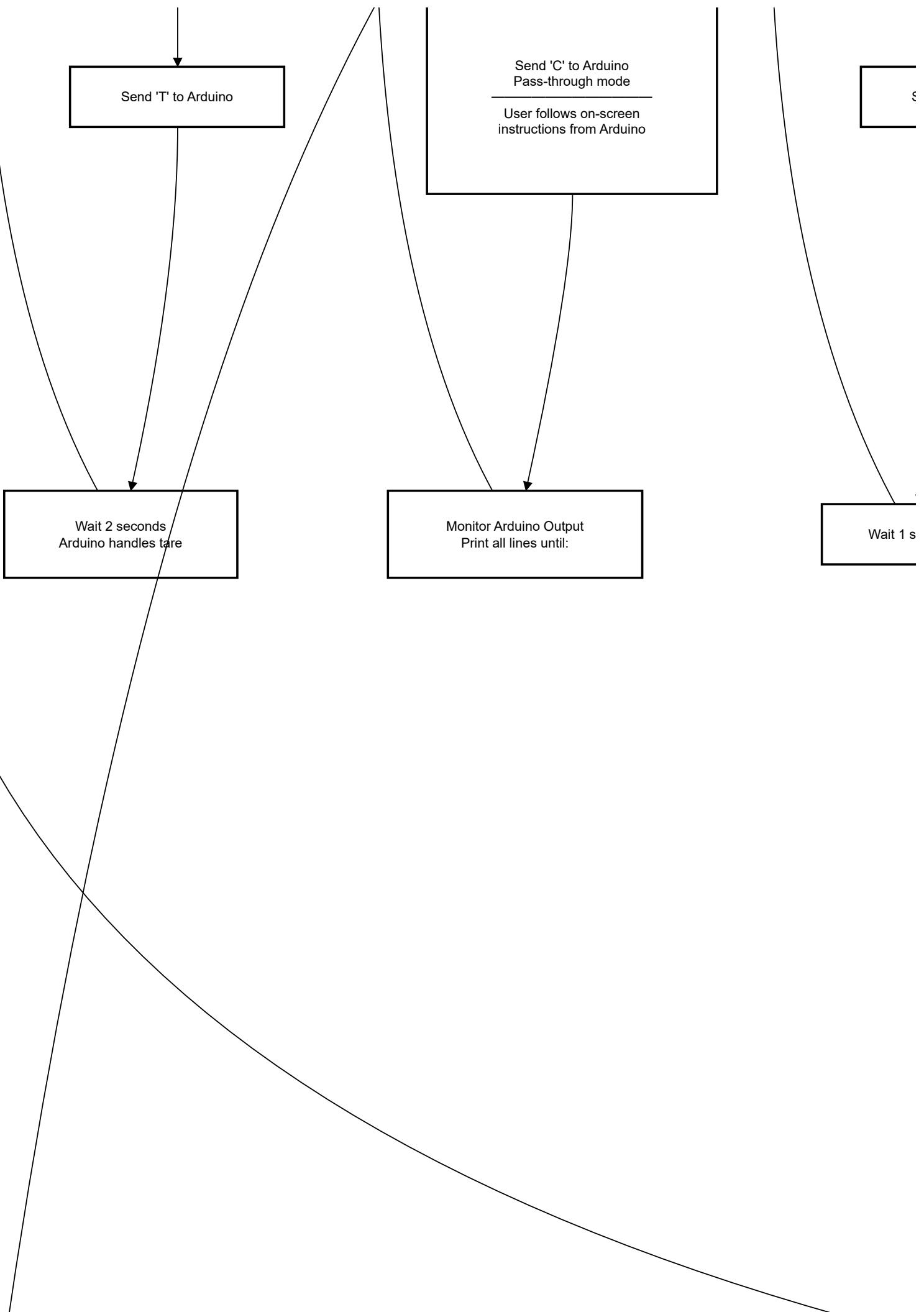
- 
- 1** save\_to\_excel()
  - 2** plot\_results()
  - 3** Close serial
  - 4** Exit program

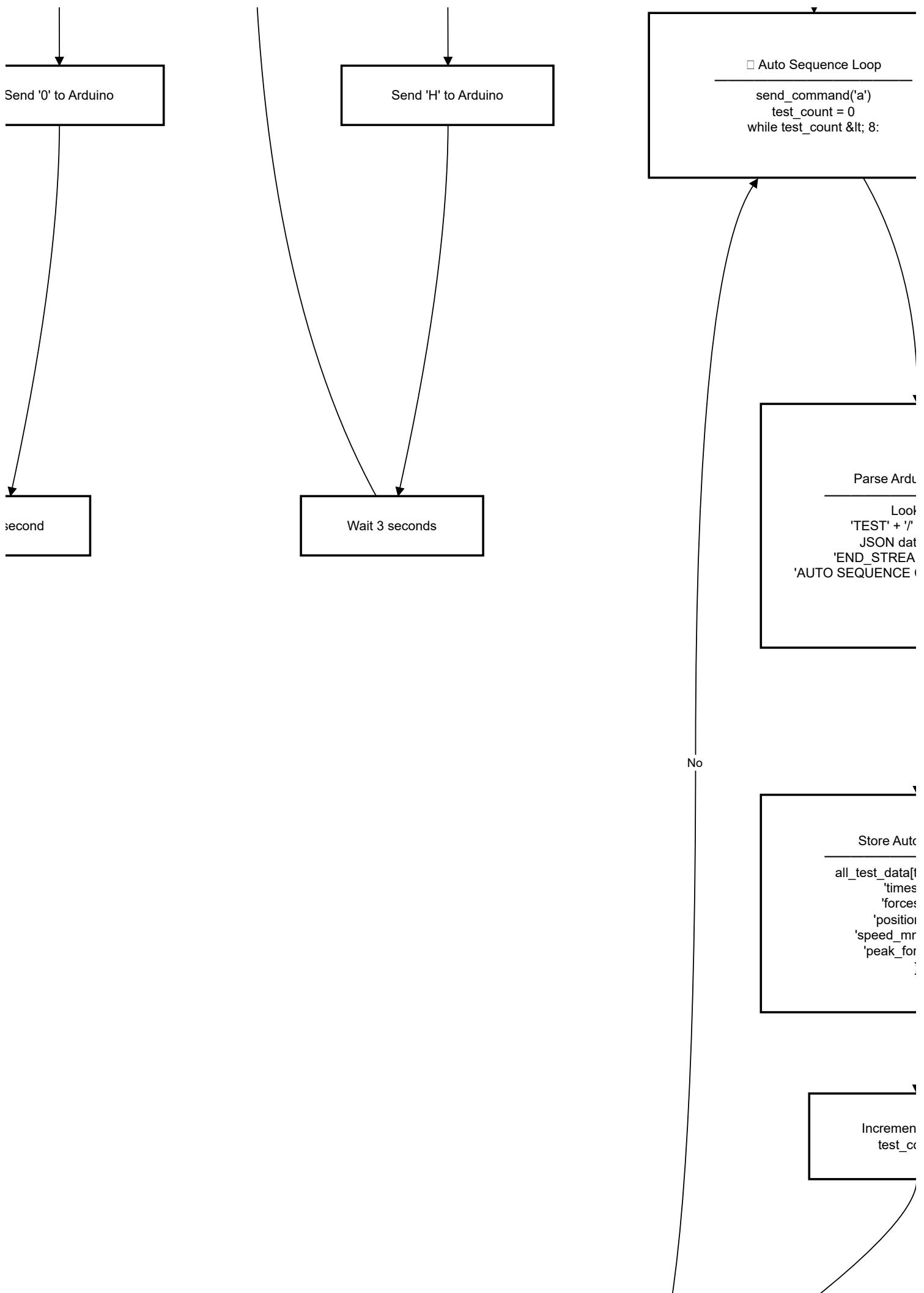


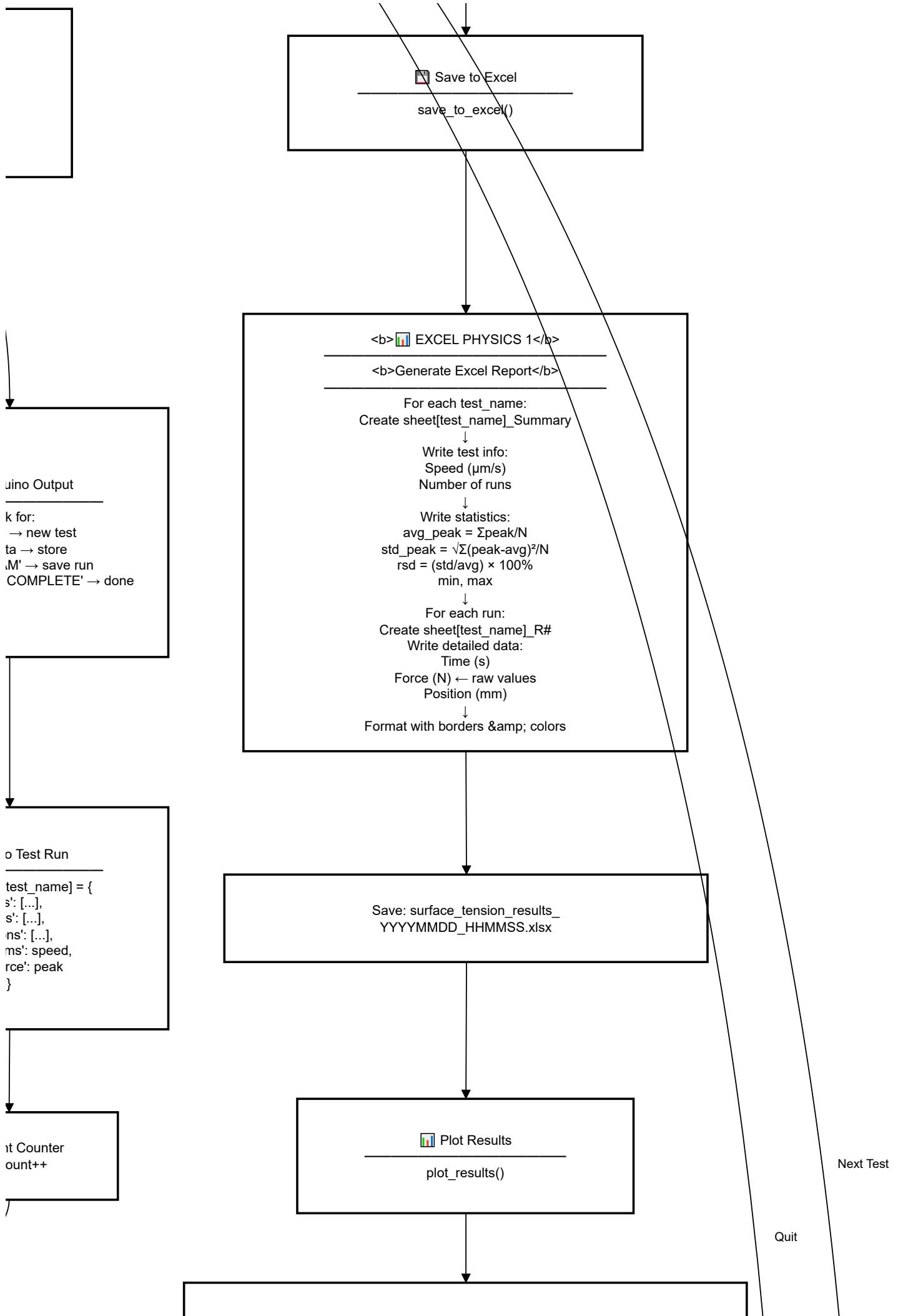
### Live Monitor Loop

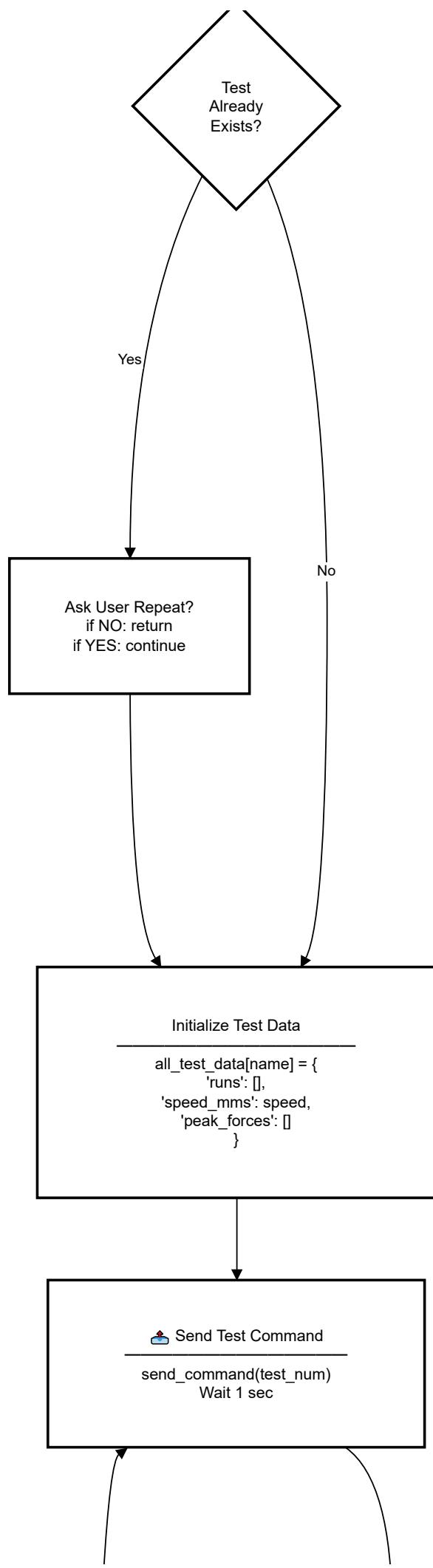
```
Read from serial:  
if 'Force:' in line  
print(line, end='\r')  
← Overwrite each update  
if Ctrl+C pressed:  
send_command('q')  
return to menu
```

Yes



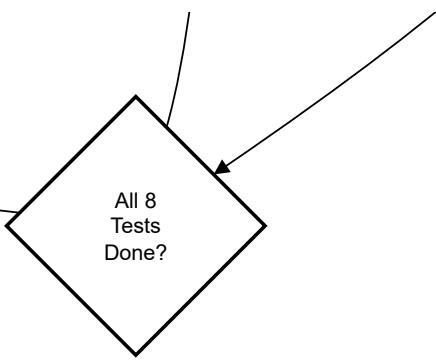






'Q'





<b> PLOTTING PHYSICS 1</b>

<b>Find Contact Point</b>

```
find_contact_point():
for i in range(len(forces)):
    if forces[i] < 0 AND
        forces[i+1] ≥ 0:
        ← Force crosses 0
        contact_idx = i + 1
    return contact_pos
```

Physics meaning:  
Ring enters liquid  
Buoyancy creates  
negative force

<b> PLOTTING PHYSICS 2</b>

<b>Find Peak Force</b>

```
find_peak_force():
peak_idx = argmax(forces)
peak_force = forces[peak_idx]
return peak_force, peak_idx
```

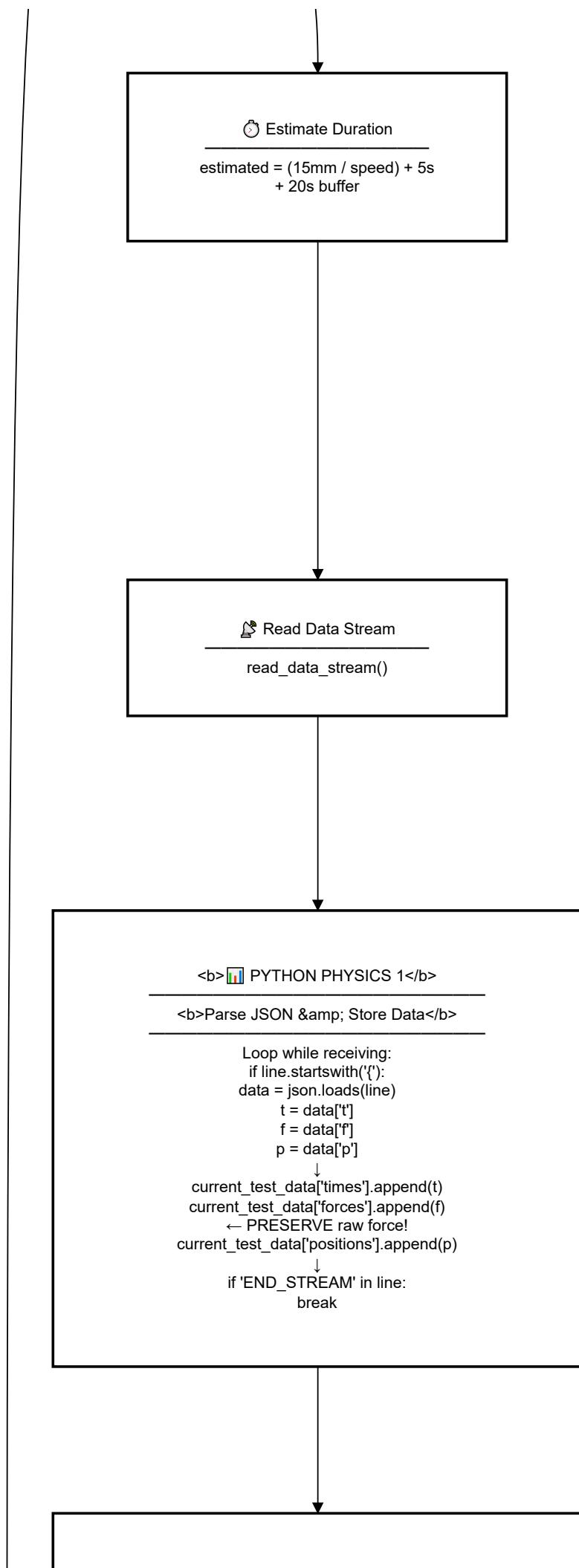
Physics meaning:  
Maximum pull force  
= Surface tension effect

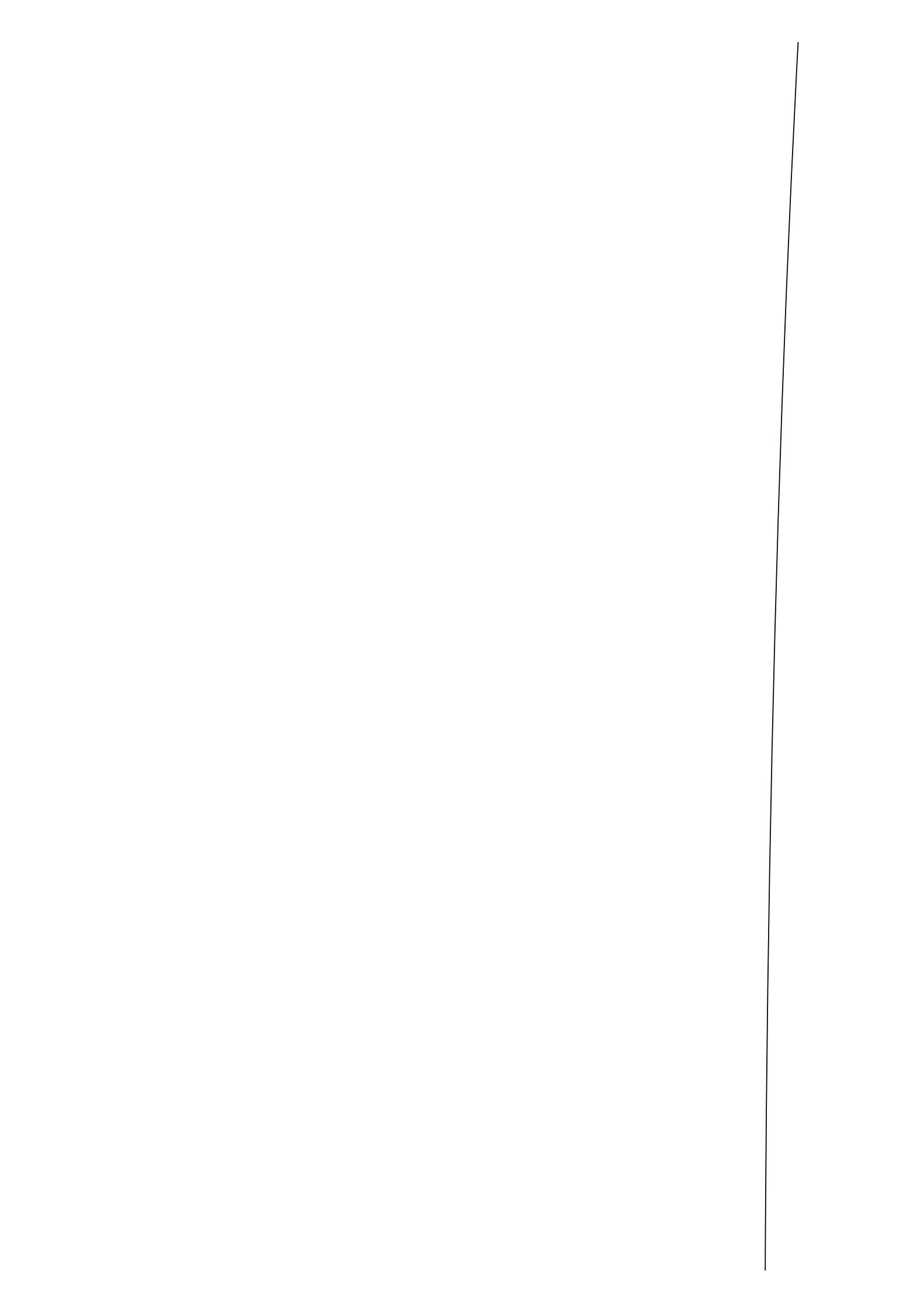
Plot Layout (2 columns per test)

Left: Full curve view  
Right: Zoomed contact view

Sort by speed HIGH→LOW

Plot Full View (Left)









```
ax_full.plot(positions, forces)
```

- 
- ✓ Add elements:
  - ✓ Zero-force reference line
    - color: #505050 (gray)
    - linewidth: 0.6
  - ✓ Contact marker (square)
    - color: accent
    - markersize: 6
  - ✓ Peak marker (circle)
    - color: accent
    - markersize: 6
  - ✓ Peak annotation box
  - ✓ Grid (alpha=0.2)

#### Plot Zoom View (Right)

---

Auto-zoom parameters:  
zoom\_x\_min = contact\_pos - 0.05mm  
zoom\_x\_max = contact\_pos + 0.1mm  
zoom\_y\_min = -0.0002N  
zoom\_y\_max = +0.001N

---

Display:  
Magnified contact region  
Zero-force line (thicker)  
Contact marker (larger)  
Grid (alpha=0.3)

#### Format Axes

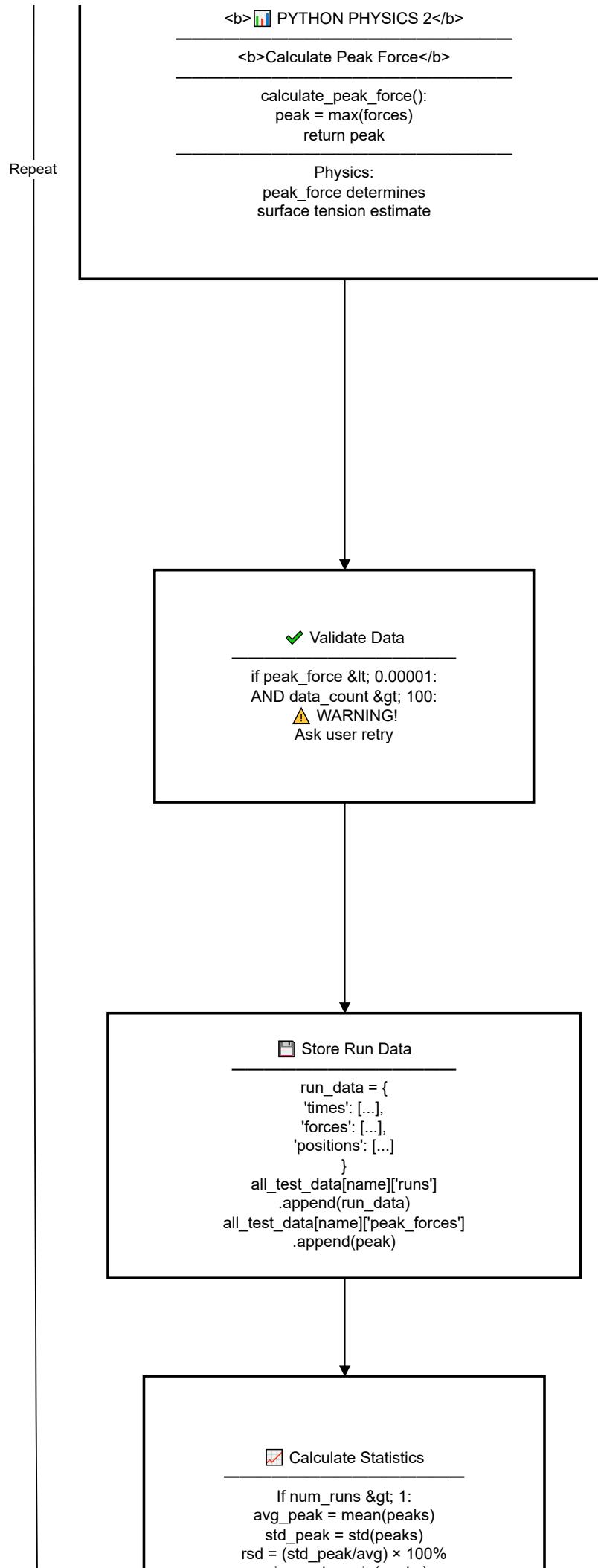
- 
- X-axis: Displacement (mm)
    - Y-axis: Force (N)
  - Title: test\_name + speed
  - Font: Times New Roman
    - Size: 10pt
  - Grid: on (minimal)
  - Remove spines: top, right
    - Tight layout

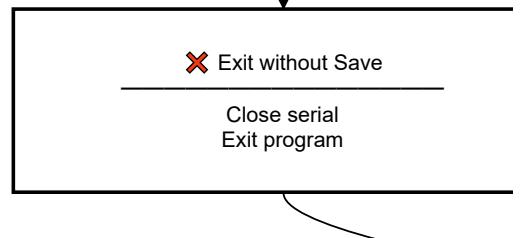
#### Save Plot to PDF

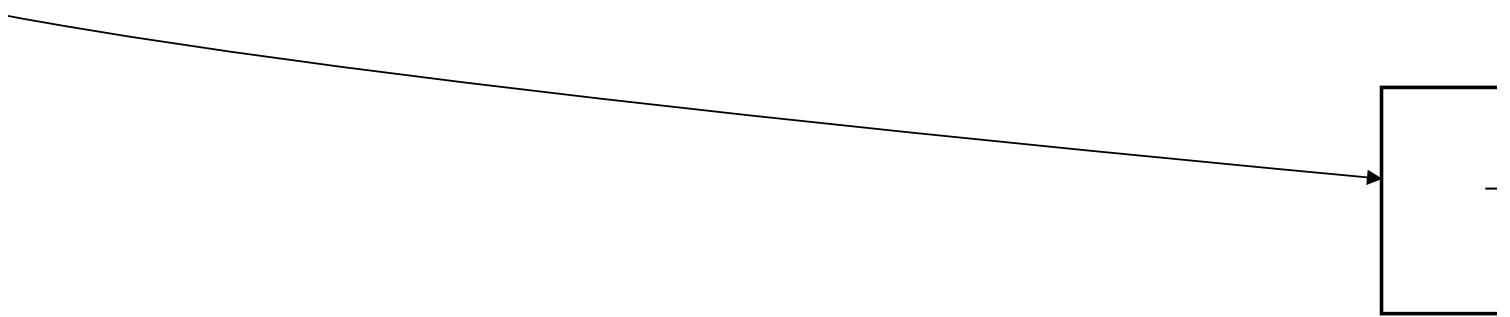
---

Filename:  
surface\_tension\_plot\_  
YYYYMMDD\_HHMMSS.pdf

---







Program Complete

Close serial connection  
Exit

Resolution: 300 DPI  
Format: PDF  
Path: output\_dir

Display on Screen  
plt.show()

```
min_peak = min(peaks)  
max_peak = max(peaks)
```

Display Results

Print:  
Peak Force (N)  
Data Points  
Statistics (if multiple)

Continue  
Testing?

