

PyLabRobot Protocol Simulation Report

Task Summary

Simulated a PyLabRobot liquid-handling protocol that transfers 20 μL from well A1 to well A2 on a 96-well plate (360 μL capacity). The original script incorrectly attempted to aspirate 120 μL from A1, which only contained 100 μL initially. The simulation correctly caught this volume violation. The fix corrected the aspirate volume to 20 μL (matching the intended transfer volume), and the simulation passed.

Initial Conditions

Well	Initial Volume (μL)	Capacity (μL)
A1	100	360
A2	0	360
All other wells	0	360

Original Protocol (in/protocol.py)

```
async def protocol(lh, plate, tips):  
    await lh.pick_up_tips(tips["A1"])  
    await lh.aspirate(plate["A1"], vols=[120])  
    await lh.dispense(plate["A2"], vols=[20])  
    await lh.return_tips()
```

Original Simulation Result: FAILED

Error: TooLittleLiquidError: Not enough liquid in container: 120.0uL > 100uL.

The simulation stopped after picking up tips (step 1). No aspiration or dispensing occurred. Volume balance remained at 100 μL total.

Original Simulation Artifacts

Output directory: out/lab-simulation-096eedc9d13f/

Files produced:

- report.json — full simulation report with error details
- execution.log — text log showing tip pickup then immediate stop
- events.jsonl — binary event stream
- well_volumes.csv — well-by-well volumes (unchanged: A1=100, A2=0)
- initial_volumes_uL.json — input volumes
- manifest.json — run metadata
- protocol.py — copy of the script that was simulated
- simulation.py — simulation harness

Fixed Protocol (out/protocol_fixed.py)

```
async def protocol(lh, plate, tips):  
    await lh.pick_up_tips(tips["A1"])  
    await lh.aspirate(plate["A1"], vols=[20])  
    await lh.dispense(plate["A2"], vols=[20])  
    await lh.return_tips()
```

Fixed Simulation Result: SUCCESS

All 4 operations completed: pick_up_tips → aspirate 20 μL from A1 → dispense 20 μL to A2 → return_tips.

Volume balance: 20 μL aspirated, 20 μL dispensed, residual 0 μL . Total liquid conserved at 100 μL .

Final Well Volumes After Fixed Protocol

Well	Initial (μL)	Final (μL)	Change (μL)
A1	100	80	-20
A2	0	20	+20
All other wells	0	0	0

Fixed Simulation Artifacts

Output directory: out/lab-simulation-696dd387bc09/

Files produced:

- `report.json` — full simulation report with `success=true`
- `execution.log` — text log showing all 4 steps completed
- `events.jsonl` — binary event stream
- `well_volumes.csv` — well-by-well volumes (A1=80, A2=20)
- `initial_volumes_ul.json` — input volumes
- `manifest.json` — run metadata
- `protocol.py` — copy of the fixed script
- `simulation.py` — simulation harness

Key Observations

- The original error was caught in software simulation before any hardware would be involved — demonstrating the value of simulation-first workflows.
- The fix was minimal: changing aspirate volume from 120 μL to 20 μL to match the intended transfer volume.
- The 96-well plate (`cor_96_wellplate_360uL_Fb`) has 360 μL capacity per well; both A1 (80 μL final) and A2 (20 μL final) are well within limits.
- Hamilton 1000 μL filter tips (max 1065 μL) were used; 20 μL is well within tip capacity.
- Volume tracking remained balanced throughout: initial total = final total = 100 μL.