Safe Operating Procedure:
Window Washer Testing

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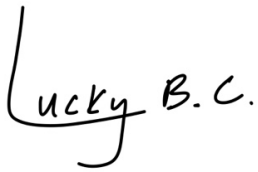
Date Approved:	Click or tap to enter a date.

Approved by:	Signature
[Approver's name.]	
[Facility Manager]	

Acknowledgement:

By my signature I acknowledge that I have read and understand the contents, requirements, and responsibilities outlined in this SOP.

Name (Print or Type)	Signature	Date
Lucky Babcock-Chi		5/24/2025
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1. Description

This SOP describes a test to evaluate the functionality of a window-washing mechanism. The test setup consists of a 16 by 20-inch glass pane mounted to a frame using nails and structural supports. A squeegee, mounted to a 3D-printed arm, performs the cleaning operation. The arm is attached to an 800 mm 2020 V-Slot rail and driven by a gantry system. A water delivery system, composed of a garden hose, PVC components and adapters, is integrated into the gantry to supply cleaning fluid to the window surface. Control electronics—including a stepper motor, an Elegoo Uno microcontroller, and drivers—are mounted in a 3D-printed enclosure at one end of the V-Slot. Limit switches are positioned externally along the frame for motion control feedback.

2. Hazards Overview

- **Bodily Harm -** The test involves a mounted glass pane that may shatter under stress or impact, posing a risk of cuts or flying shards.
    - Recommended wear: close-toed shoes, long sleeves, and long pants during operation to reduce the risk of injury from broken glass.
- **Electric Shock -** The system relies on standard components (e.g., microcontroller, motor drivers), which may fail due to loose wiring, component faults, or power issues. Water from the plumbing system may also leak and encounter electronic components, increasing the risk of short circuits.
    - Ensure all electrical connections are secure before operation. Confirm that all plumbing connections are watertight, and keep electronics sealed and elevated away from potential water exposure. Do not operate the system unattended. In the event of a malfunction or leak, immediately disconnect the system from power.

3. Required Personal Protective Equipment (PPE)

Close-toed shoes – To protect feet from falling objects, such as glass or components.

Long-sleeved shirt and long pants – To minimize skin exposure in the event of glass shattering.

Insulated gloves (optional but recommended) – When handling or adjusting electrical components, especially during troubleshooting or wiring.

4. Waste Disposal

In the event of glass breakage, gloves must be worn if handling any bodily fluids, such as blood. Carefully inspect the area to ensure there are no additional hazards or sharp fragments present. Large shards should be picked up with gloved hands or appropriate tools (e.g., tongs or dustpan) and placed into a clearly labeled container designated for broken glass or sharps. Smaller fragments should be

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swept up using a broom and dustpan and disposed of in the same designated container. Ensure the area is fully cleared of debris before resuming any work. Any waste should be clearly labeled and disposed of.

Solid waste, such as paper towels, disposable cleaning cloths, or broken 3D printed parts, should be disposed of in general waste bins.

In general, generation of waste should be kept to a minimum and all waste is to be properly labeled and disposed of according to EH&S policy.

5. Accident and Spill Procedure

Emergency Response – Although such situations are not expected, if an incident poses an immediate threat to life or serious injury, seek emergency medical assistance without delay.

- Call 911 for paramedic assistance.
- Minor cuts can be addressed using the Band-Aid station located above the sink.
- In the case of any injury associated with the project, notify faculty (e.g. teaching staff).

The lab manager must be notified in the event of any significant injury. A significant injury is any injury that cannot be addressed by the contents of the room's Band-Aid station.

The lab manager must be notified in the event of a large spill, i.e., greater than 5 gallons, or a spill of any hazardous waste.

6. Approvals Required

Permission from Dr. Marks is required to use the hose and spigot located in the EII courtyard. This approval must be obtained prior to each test involving the water delivery system.

7. Procedure

Assembly

1. Place the glass-mounted frame upright on a stable stand or test platform. Ensure that the structure is secure.
2. Connect the water delivery system:
    a. Secure the garden hose to the inlet of the PVC plumbing system using the appropriate adapter.
    b. Ensure all fittings are watertight and free of visible leaks.
3. Ensure all electronic components are positioned away from potential hazards, such as water spray, to prevent damage.
4. Place the system near a table or workstation with access to charging or power ports. Plug in all electronics but do not power them on yet.

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Pre-run

1. Attach the garden hose to a water source, if available (provided by Dr. Marks). Ensure the water is turned on at the source but keep the valve on the PVC system closed until the cleaning demonstration begins.
2. Plug in all electronics and verify that connections are secure. Do not activate the motor or initiate any control sequences at this stage.
3. Perform a visual inspection to ensure that:
    a. All mechanical components are properly secured.
    b. There are no leaks in the plumbing system.
    c. The squeegee arm is unobstructed and correctly aligned with the window.
4. Once all systems are verified and a demonstration is ready to begin, power on the microcontroller.
5. The system is designed to begin operation immediately upon receiving power.

Run

1. Once all pre-run checks are complete and the area is clear of personnel, begin system operation by powering on the electronics. The squeegee arm will begin motion across the window pane.
2. Slowly turn the PVC valve no more than ¼ turn counterclockwise to allow water to flow through the system.
    a. Do not open the valve beyond ¼ turn, as this may produce excessive spray pressure and create a safety hazard for nearby personnel.
3. The squeegee will travel from one side of the window to the other.
    a. Once it reaches the opposite end, shut off the water valve to prevent excess runoff.
    b. The squeegee will return to the starting position, cleaning as it moves back.
    c. This motion constitutes one full cleaning cycle. Multiple cycles may be performed if needed for a more thorough clean.
4. Throughout the run, monitor the following:
    a. Water flow rate – ensure controlled flow, with no splashing or leaks.
    b. Gantry motion – verify smooth, uninterrupted travel.
    c. Electrical connections – check for any signs of unusual noises, or irregular behavior.
    d. Glass integrity – ensure no visible stress, cracking, or unexpected vibration.
5. In the event of any malfunction—including electronic failure, water leakage near electronics, mechanical jamming, or glass damage—immediately stop the system:
    a. Disconnect all power sources.
    b. Shut off the PVC valve and water supply.
    c. Inspect the system and resolve the issue before resuming operation.
    d. If necessary, alert teaching staff and document the incident.

Post-Run

1. Standard Shut-Down
    a. After the demonstration is complete, shut off the valve on the PVC system to stop water flow.
    b. Unplug all electronics from the power source.
    c. Confirm that all motion has ceased and there is no residual power to the system.
2. Emergency Shut-Down:

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   a. In the event of an emergency, follow the shutdown procedure outlined in Step 5 of the Run section.
3. Cleanup:
   a. Use paper towels or absorbent cloths to wipe off any excess water from the table, window, or surrounding components.
4. Storage and Dismantling:
   a. The system is designed as a single integrated assembly; no disassembly is required following a test run.
   b. Store the glass window securely in a padded or enclosed container to prevent breakage or injury. Ensure it is upright and stable if stored vertically.

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