Steel Ball Dispenser For Lawnmower Projectile Testing

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Motivation and Background

- UL Solutions conducts lawnmower debris projectile testing
- Steel balls (500/cycle) fired at the underside of the lawnmower via a pneumatic machine
- Deflection angles measured to verify safety
- Existing steel ball funnel to load pneumatic machine gets jammed
- **Goal: design an anti-jamming steel ball dispenser**

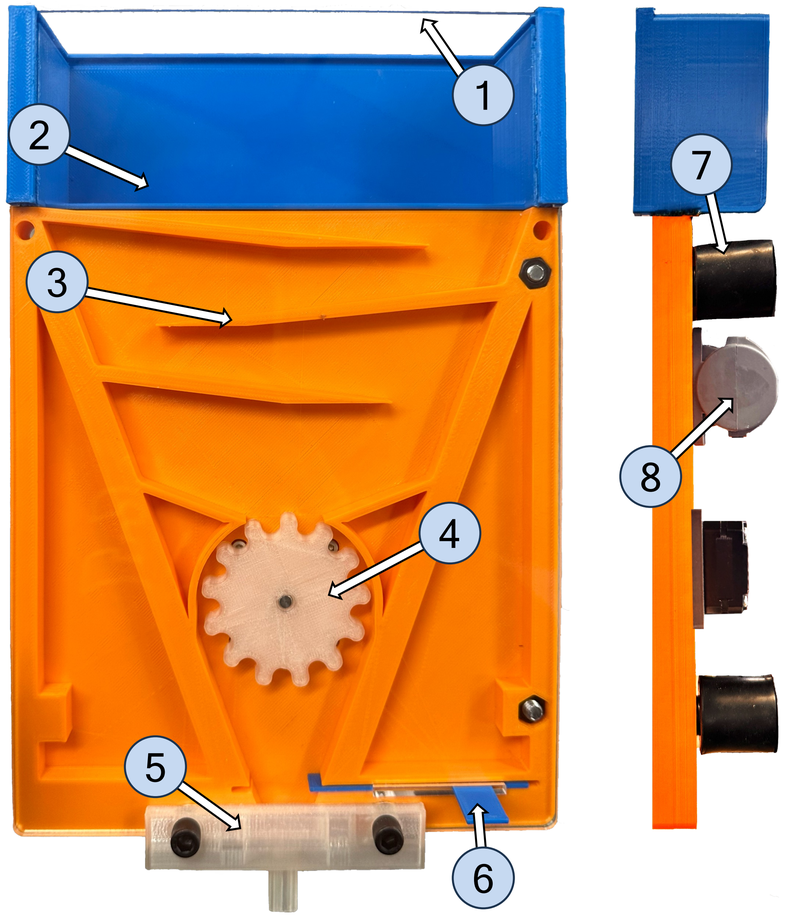
Research Results

- Objects tend to move when in a **'flow state'**
- **Vibration** aids in creating a 'flow state' between the balls
- Piling weight **increases** the risk of jamming
- Rotating wheel **promotes disturbance** and 'flow state'

Design Criteria and Test Results

Criterion (* = Constraint)	Target	Testing Process	Test
Size	Within 20% of original funnel dimensions (7.0 x 1.5 x 13.1 in.)	Measure all sides of product	Pass
Durability	Functional for > 10 years	Accelerated Lifetime Testing	TBD
Cost	Maximum of $500	Sum up component costs	Pass
Ease of Use	Requires ≤ 2 minutes to set up and average rating > 3.5/5 on user-defined scale for ease of use	Average the times taken to start system on test trials performed by different people	Pass
Enclosure	Prevents foreign objects > 0.02-in. from entering	Drop objects of varying sizes over the top compartment	Pass
Failsafe Mechanism	Method to stop dispensing in ≤ 3 seconds	Average the times taken to stop the system on test trials	Pass
User Input*	0 human input required during dispensing	Tally how many times a human must manage system after loading	TBD
Integration with Existing System*	0.5-in. diameter opening at bottom of dispenser	Measure hole at base of dispenser	Pass
Capacity*	Holds > 1,500 0.25-in. diameter steel balls	Load > 1,500 0.25-in. steel balls into storage area	Pass
Safety*	All edges rounded to a radius of ≤ 0.1-in.	Measure corner sharpness	Pass

Final Design



A. Front View B. Side View

Figure 1. Mechanical Components

1. **Acrylic Sheet**: Secures balls
2. **Ball Chamber**: Stores over 1,500 0.25-in. diameter steel balls
3. **Alternating Tracks**: Guide balls to gear and relieve gear of weight
4. **Rotating Gear**: Accepts and dispenses one ball at a time
5. **Exit Hole Adapter**: Allows dispenser to attach to 0.5-inch diameter pneumatic tube
6. **Sliding Bar E-Stop**: Stops dispensing of balls in case of an emergency
7. **Rubber Vibration Isolators**: Isolate dispenser system from the wall for more effective vibration
8. **Vibration Motor**: Vibrates dispenser to prevent jamming in chamber and alternating tracks

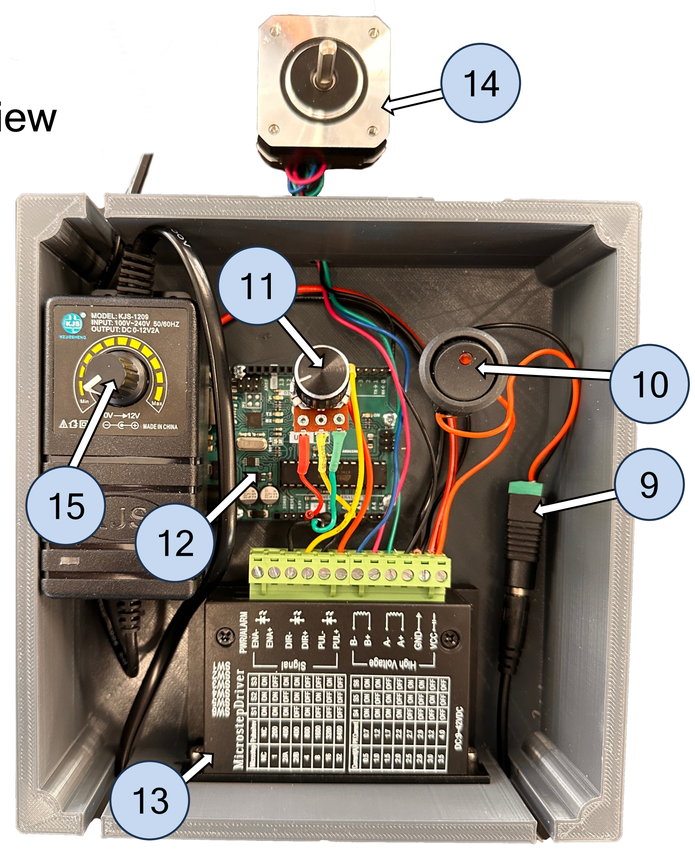


Figure 2. Electronic Components

9. **Power Supply**: Supplies 12V DC to circuit
10. **Power Switch:** Turns power on/off to circuit
11. **Potentiometer**: Modulates analog input into Arduino
12. **Arduino Uno:** Reads input from potentiometer and sends output to microstep driver
13. **Microstep Driver:** Spins motor
14. **Stepper Motor:** Rotates attached gear
15. **Vibration Motor Knob**: Modulates frequency of vibration

Future Work

- Replicate design with stronger material (e.g. resin)
- Implement microswitch to automatically de-activate system when e-stop is slid shut

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