

Obot Project Development Log

About the Obot:

The Obot is an automated oboe performance system that uses a real double reed and a layered airflow control mechanism to reproduce human oboe playing. The system integrates a pump, a servo controlled vent, and a mechanical reed clamp to achieve precise pressure regulation, while a 3D printed bridge with eight solenoids provides key actuation for the main and octave keys. Obot can reliably perform excerpts from Swan Lake and produce stable pitches across the G4–C6 range. This project demonstrates a practical approach to automating double reed instruments and establishes a foundation for future developments.

1. Initial Exploration: Getting the Reed to Vibrate

Playing a double reed instrument like the oboe requires extremely delicate embouchure control—the lips fold inward to gently pinch the reed, adjusting pressure with great precision.

I purchased a small air pump that came with a silicone tube roughly 1 cm in diameter. I inserted the reed into one end of the tube and used my thumb and index finger to simulate the pressure normally applied by human lips. This setup successfully produced sound—the reed only needs sufficient airflow and slight compression produced by the fingers for its two blades to vibrate.

2. Replacing Human Input with Mechanism

To eliminate the need for manual pressure, I replaced the finger grip with a metal clamp (a single-sided iron clamp where tightening the lower screw brings the jaws together to pinch the reed, effectively simulating the pressure of my fingers). This worked, but because the reed blades sit extremely close together, even a minimal change in pressure can prevent it from sounding. To achieve precise control, I mounted the clamp onto a 360-degree servo motor—allowing me to adjust tension electronically.

My first attempt at controlling the clamp with the servo was unstable.. Two wooden sticks were used as support, but the structure lacked rigidity. When the servo rotated, the clamp would shift side to side, and the hot glue did not provide long-term adhesion, making the setup unsuitable for repeated

operation. After 3D printing a sturdier base to hold the clamp and servo, the system became significantly more reliable.

3. Transferring the System to the Oboe

Once the reed was connected to the oboe, I encountered new challenges: the instrument wouldn't sound consistently. Finding the right balance between clamp tension and airflow could take up to 10 minutes each time. This was a major problem because if I were to perform or demonstrate in public, a 10-minute setup time would be unacceptable. It had to be reduced to about one to three minutes. Moreover, if a failure occurred during a performance, re-tuning could again take another 10 minutes. The long adjustment period mainly resulted from hardware instability, and with extended use, the tuning time could even exceed 20 minutes.

The original silicone tube was too narrow, causing unwanted pressure on the sides of the reed, increasing the distance between the two blades. Since sound is produced by the vibration of the two blades against each other, this separation made it much harder to generate vibration and therefore sound. Replacing it with a larger tube greatly improved both stability and response (a diagram will be added later).

4. Mechanizing the Key Action

With the reed functioning, I moved on to automated key control. I first experimented with servos, but 180° servos lacked strength, and 360° servos were too bulky and lacked precise angle control—both critical for fast, reliable execution. I then switched to solenoids. Since the oboe's main six keys are vertically aligned, I mounted six solenoids in a straight row above them.

I designed a 3D-printed bridge structure to hold the solenoids. Each solenoid was inserted into a custom 3D-printed housing with screw holes on top for mounting. The bridge was printed parallel to the oboe and positioned directly above it. The width of the solenoid housings matched the inner width of the bridge, allowing me to secure the solenoids with screws while also enabling them to slide horizontally for precise positioning above each key.

I built two wooden pillars to support the oboe at the correct height. After printing custom housings and attaching them with screws, everything fit well. However, the metal-on-metal contact between solenoids and keys caused slipping, and the keys' air holes needed to be sealed. Adding silicone pads to each key resolved both issues.

I eventually expanded the system to eight solenoids, including both octave keys.

5. Precision Airflow Control: The Key Breakthrough

As I began testing musical passages, I noticed that each note required a unique airflow and air pressure to sound clearly. The clamp-and-pump setup lacked the responsiveness needed for smooth transitions. PWM control of the pump helped somewhat but was still too coarse.

The breakthrough came when I cut a 1 mm² vent hole into the silicone tube. Blocking this hole with my finger allowed me to vary internal pressure continuously, providing much finer control over airflow to the reed. I then mechanized this technique using another servo-driven clamp positioned over the vent hole, allowing programmable adjustment of airflow instead of relying on finger pressure.

With the combination of clamp control and vent control, I reduced setup time dramatically—from 10 minutes to just 1–3 minutes.

6. Note Range and Real-World Limitations

The system theoretically supports the following notes:

D4, E4, F4, F#4, G4, A4, B4, C5, D5, E5, F5, F#5, G5, A5, B5, C6, C#6, D6.

In practice, the most stable notes are:

G4, A4, B4, C5, E5, F5, F#5, G5, A5, B5, C6.

**Theoretical
Notes**

Stable Notes in Practice

D4–D6	G4, A4, B4, C5, E5, F5, F#5, G5, A5, B5, C6
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The stable notes require similar air pressure and can be played smoothly in succession.

The most difficult note is D5, which demands exceptionally precise airflow. Tiny variations can make it unstable. Especially in transitions such as C5 → D5 → E5, each note requires drastically different airflow. C5 only uses two keys, while D5 needs five keys pressed simultaneously. E5 is also challenging, involving up to six keys, but it is slightly easier because it can be played with the octave key, unlike D5, which is the highest note playable without the octave key.

To address this, I reinforced each key to ensure that every solenoid could fully push down its corresponding key. I redesigned the solenoid heads to have a square surface area almost identical to that of the oboe keys and increased the silicone pad thickness under each key. This enlarged the contact surface, improving pressing stability and reducing the likelihood of incomplete actuation. As a result, the success rate of producing D5 has improved significantly.

7. *Swan Lake*

With reed control and key actuation functioning reliably within a limited pitch range, obot is now capable of performing excerpts from *Swan Lake* with reasonable consistency.

8. Future Improvements

Currently, each reed's blade spacing varies slightly due to manufacturing differences. This means that the airflow and clamp pressure required to make each reed sound are never identical. Because the lifespan of a reed typically ranges from two weeks to one month depending on usage, every time I replace a reed, I need to recalibrate the airflow and pressure settings for each note.

To solve this, I plan to develop a software system capable of automatic tuning. By using a tuner to detect pitch, the software could control the servos to adjust

both airflow and clamp pressure until the target pitch is reached. Once calibrated, the system would memorize each note's parameters—air pressure and clamp strength—creating an automatic self-tuning mechanism.

Currently, the obot is still three keyholes short of achieving the full oboe range. Many of the lower oboe keys share common tone holes; for instance, the bottom three keys operate only two tone holes. Therefore, placing solenoids over those two holes can replicate the function of three separate keys. I've calculated that controlling three additional tone holes would enable obot to perform the entire range of the oboe. However, since these tone holes are located on the side of the instrument rather than along the central line, I will need to design and 3D print angled supports to mount the solenoids accurately over them. This will require partially dismantling and modifying my current structure.