EML 4501 – Summer 2020 – Team 2
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Bellow Zero 3D BioPrinter

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Product Overview

Bellow Zero is a 3D printer for biological materials designed with accuracy and precision in mind. The product mounts directly onto a microscope to allow immediate and concurrent imaging and printing all in one location. The movement of the print head is controlled by the expansion or contraction of three fluid-filled nylon bellows. This design keeps the motors, gears, controller, and power supply mounted to the wall, away from the microscope and off the lab table, so the system does not occupy any table space. This also minimizes vibration of the microscope, print head, and well plate, ensuring accurate printing and imaging.

Product Functionality

The system implements four position-control DC motors, each with the ability to accurately move in increments of 0.007 degrees with 10,000 steps per rotation, which combine with rack and pinion gear systems to control the volume of four syringes. Three syringes are used to pressurize the bellows system, and one syringe is used to dispense/collect the desired print material. Each bellow operates in one cartesian axis of motion and builds off one another, so the print head can travel through the entire volume of a well with ease. The movement of the print head is controlled by either increasing or decreasing the volume within each of the bellows.

Disposable Print Mechanism

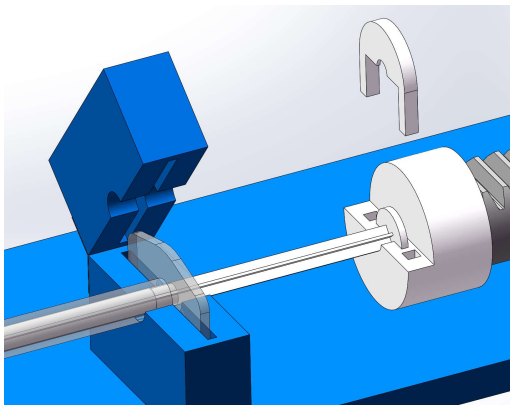

Figure 5. The syringe retention mechanism. The syringe is easily replaceable to clean and allow for printing various types of cells. Customizing the syringe size allows for more precise motion of the bellows. The print medium syringe can be changed to vary volumes of print material.

Full System

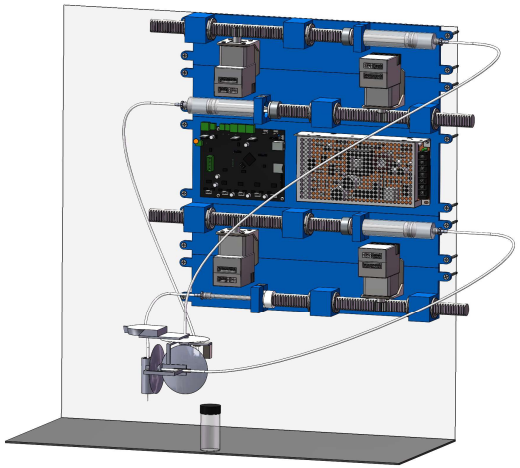

Figure 1. Assembly of Bellow Zero. The system is comprised of two main assemblies: 1) The print head and bellows and 2) the motor and syringe assembly.

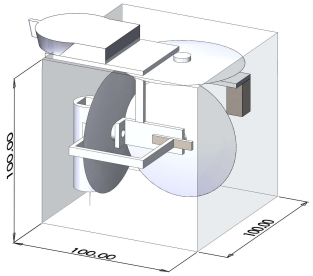

Figure 2. The main print head assembly which mounts to the microscope. The assembly fits within a 100mm cube when the bellows are empty.

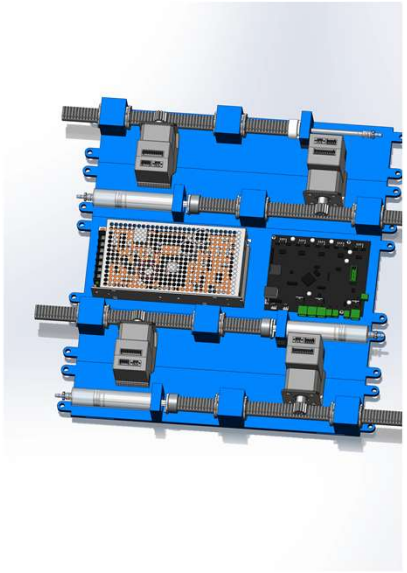

Figure 3. The wall-mounted motor and syringe assembly. The assembly is comprised of 5 interlocking base plates which can be screwed into a wall. The modularity allows for a single person to easily mount the assembly.

Bellows

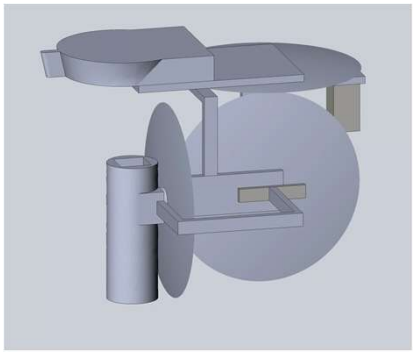

Figure 6. A system of three bellows are connected in succession by brackets and allow movement to be translated to the cell delivery needle. The system is made of nylon given its high strength and achievable displacement. A counterweight system is used to manage needle alignment with the vertical axis.

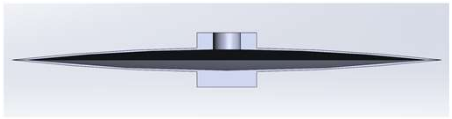

Figure 7. Section view of single bellow in resting state. Thin-walled pressure vessel analysis was applied.

Cost Estimate

OTS Parts: $2,397.28
Raw Materials: $25.95
Manufacturing and Labor: $133.51
Energy Consumption: N/A to processes used
Assembly Labor: 23.25

Total Cost: $2,579.99

Syringe Motor System

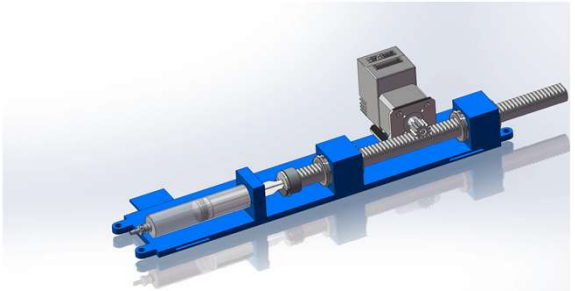

Figure 4. The syringe and motor assembly on 3D printed base. A stepper motor drives a rack and pinion gear to push the plunger into the barrel in order to deposit and extract material. This system is used for the print material as well as filling the bellows.

Needle Holder

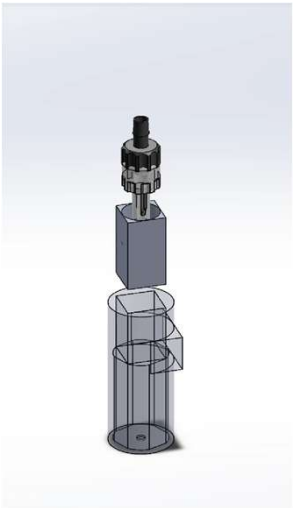

Figure 7. The needle holder mount assembly. A cubic shaped casing is fitted to the needle. The needle and casing assembly is inserted into a vertical cubic slot in the cylindrical mount

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Customer Needs Map

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