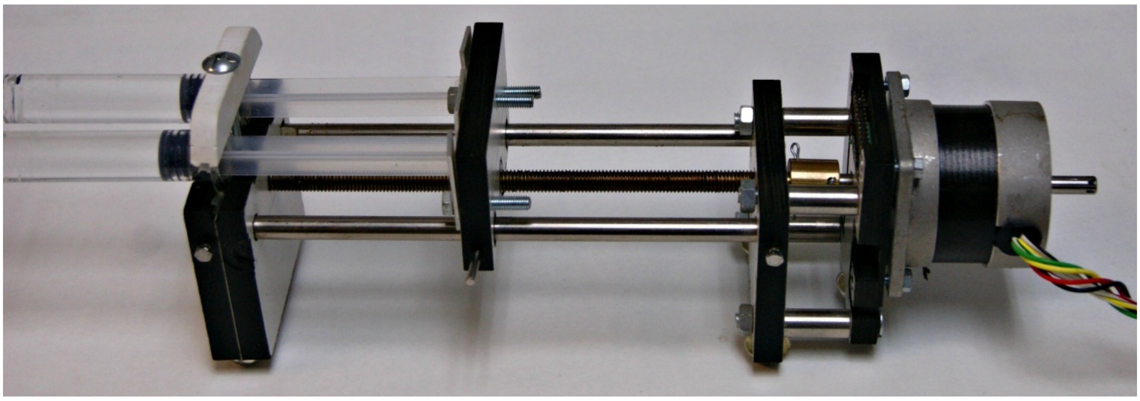
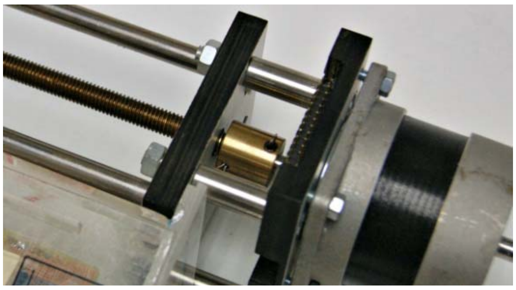
MECHANICAL SETUP



The main component of the mechanical setup is the linear motor, a device capable of moving something along a direction. Its choice can determine both the mechanical and electronic setup to ensure the technical specifications required for a syringe pump. A cheaper option to a linear motor is a rotary motor equipped with a linear actuator to transform the rotary motion to linear. There are several possibilities when choosing the motor type; all of them allow precise control of its movement both as to its length and its speed: the servo, the DC and the steeper motors.

In DC motors, the cheapest option, the rotation speed is proportional to the supply potential. So, by changing the potential, the motor movement can be controlled. If torque exceeds the motor capacity, information on motion control is lost because the motion is no longer dependent on the potential. To avoid this you need to include some position sensor that allows full control, this is what the servomotors do. The encoder is integrated in the servo and a relatively sophisticated controller is needed, often a dedicated module specifically designed for each servo. All this extra technology represents a significant increase in the final cost.

The stepper motors represents the intermediate solution. We can accurately control the angle and direction of rotation and a generic driver can be used with any of such engines; so, a good enough control is achieved with a reasonable cost. The overload trouble is not completely avoided by working with this type of engines, so it’s advisable to design oversized systems capable of pushing liquid even in the worst conditions. We have selected the RS Components part nr. 440-458 (bill of materials’ part nr. uCF0001), a hybrid stepper motor type powered with 12Vdc@0.6A. This motor is able to rotate in steps of 1.8 degrees (full step, 257 steps by revolution) or 0.7 degrees (half step, 514 steps by revolution).

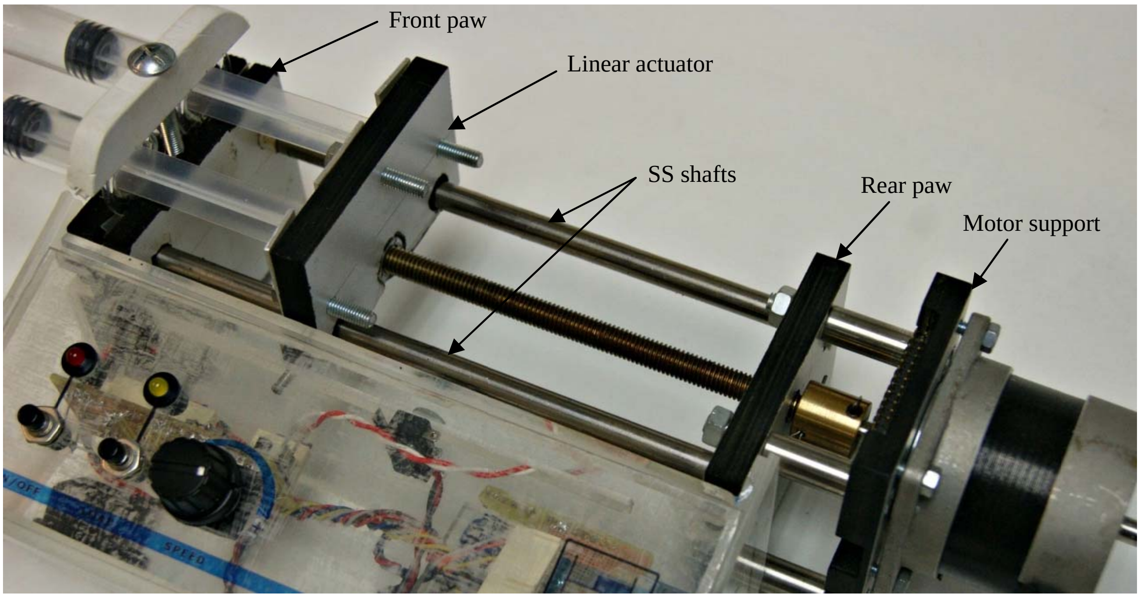


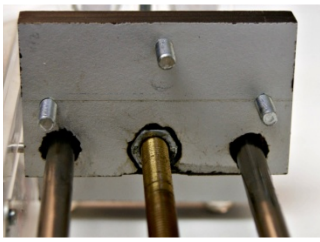
To translate the rotary motion of motor into a linear motion we have designed a linear actuator. The main component is a threaded rod M8 (bill of materials’ part nr. uCF0002) attached to the motor shaft with a home-made adapter (bill of materials’ part nr. uCF0003). Both adapter and rod were made of brass though other materials can be used. The threaded rod rotates together with the motor shaft and acts as a worm screw. So, as the rod’s thread is M8, the thread pitch is 1.25 mm and each motor half-step turn (0.7º) implies a linear motion of 2.43 microns for a nut (bill of materials’ part nr. uCF0004) that is inserted in the screw. Although the threaded rod can be purchased at any hardware store, both ends must be machined for proper placement in the holder and to connect it to motor.

The adapter for attaching the motor shaft and the threaded rod is a cylindrical piece made on a lathe from a brass rod. The piece was drilled along its axis, so that the motor shaft fits into the bore on one side and the rod on the other. To prevent the parts to rotate freely, they have been made two small through-holes in which a split pin is inserted. These cross the adapter from side to side along with the shafts, which have been also drilled perpendicularly. The central bore of the adapter was machined slightly wider than the shafts should host. This clearance allows a small elbow-joint, thus facilitating the placement of the shafts and relaxing their mutual alignment.

To support the motor/worm screw assembly and lining up both, it has been designed a holder which also facilitates the movement of an actuator attached firmly to the aforementioned nut inserted in the worm screw. The structure consists on a set of pieces of plastic material (bill of materials' parts nr. uCF0006 to uCF0009) that can be cut from a 1 cm thick griddle with an electric jigsaw and a guide. Alternatively they can be printed in 3D from their CAD-CAM models.

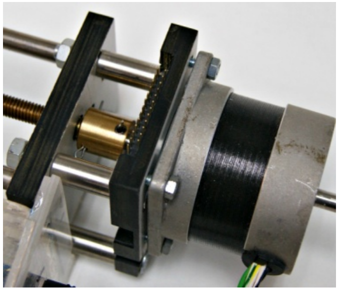
Two of pieces are the structure paws and, furthermore the worm, they supports two parallel stainless steel shafts that guide the movement of the linear actuator avoiding its rotation. The linear actuator is driven by the rotary motion of the worm screw, so the screw must be secured to avoid shifting back and forth, but still being able to rotate on its axis. The guide shafts are firmly attached to the paws by grub screws and must be accurately aligned. To facilitate this, the mounting holes should be slightly larger than the shaft diameter and small wedges can be used where needed.

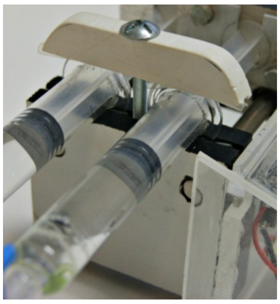




The linear actuator is traversed by both the screw and the shafts. Its movement is driven by the nut inserted in the screw, so the nut should not turn when the screw does. As a result, we must make a hexagonal hole to fit and glue if necessary the nut. The actuator must slide smoothly on the shafts; linear bearings can be used to reduce friction but a cheaper option is a brass/nylon bushing fitted to the shaft diameter and properly lubricated. Both shafts and bushing can be acquired easily and also they can be recovered from the mechanism of an old desktop printer or scanner.

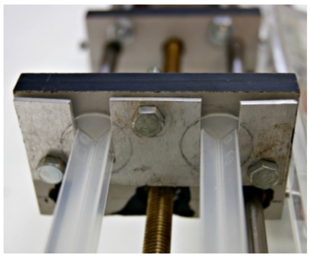
The last plastic piece is to support the stepper motor. It is attached to the rear paw toward a set of flat head bolts. To make room for the shaft/screw coupler, spacers are used between the rear paw and the motor support. The spacers are some pieces of pipe that are placed between the two parts and through which the bolts are inserted. Finally, motor is mounted by four flat-head bolts.





To mount the syringes the front paw is double thick. By this way a groove is machined on top side to hold the barrel collar of syringe. This avoids the back and forth shifts when pushing or pulling the syringe piston. The groove can be machined with an electrical rotary multi-tool and the accessories needed to guide and routing. To complete lock the syringe to paw an upper grip is designed. Actually a double syringe system is designed, so a double grip for two identical syringes is used. Any other design is possible upon demand.

The setup described by now is able to push the syringe plunger and infuse liquids. If we would withdraw fluids we need to pull the plunger without manual intervention, so the plunger must be fixed to the linear actuator. A plastic or metallic piece was attached to the actuator leaving a slot to insert the plunger collar. This way, by reversing the motor rotation, we can pull the syringe plunger at controlled speed.



The dimension drawings of all fabricated parts and the assembly drawings are available for free. Also the BoM with indication of where to find sellers for each item are available.