Hydraulic Ram Pump
Pump water with no electricity, no gasoline, just gravity!

by habolooby in energy
http://www.instructables.com/id/Hydraulic-Ram-Pump/

Introduction: Hydraulic Ram Pump

Pump water with no electricity, no gasoline, just gravity!

Sound crazy or impossible? Don't worry, it does obey the laws of physics, but I'll try to explain the operation later. This instructable shows how to build a fairly simple water pump that needs no energy input other than water flowing from a higher point to a lower point. Most of the pump is constructed from PVC, with a couple of bronze pieces thrown in for flavor. I was able to source all

of the parts from a local hardware store (Lowes) for a bit under $100.

To function, the pump does require a reasonable amount of water that will drop at least 3'-5'. The level that the pump can raise water to depends on the water's head (total drop the water will make).

This design was worked out by Clemson University.

If you like what I've done, please take the time to give it a rating, and I'd love to hear your input. Thanks!

Step 1: Bill O' Materials

Before you can really do much, you've got to go out and buy some stuff. One of those sad facts of many projects. But if you want to build this (and it's a lot of fun to see it work), print out this list and head to the plumbing dept of your hardware store.

Materials for the Pump

- 1-1/4" valve
- 1-1/4" tee (buy two of these)
- 1-1/4" union
- 1-1/4" brass swing check valve
- 1-1/4" spring check valve
- 3/4" tee
- 3/4" valve
- 3/4" union
- 1-1/4" x 3/4" bushing
- 1/4" pipe cock
- 100 psi gauge
- 3/4" x 6" nipple
- 4" x 1-1/4" bushing
- 4" coupling
- 4" x 24" PR160 PVC pipe
- 4" PVC glue cap
- 3/4" x 1/4" bushing

- Short (4') section of 1-1/4" PVC pipe
- Old Bicycle Innertube

This parts list comes directly from the Clemson website. I recommend you look there for help in identifying what each of the pieces look like, if you're unsure. I'm also not convinced that the 100 PSI gauge, or all of the things that make it possible, are necessary. This will probably drop the price a good bit, and I haven't found a need for it on my pump. The associated pieces are: 100 PSI gauge, 3/4" Tee, 3/4" x 1/4" bushing, the 1/4" pipe cock. Four things not needed. But have them if you like.

Connections Note Read through the instructable and understand all the pipe-fitting connections that will happen before buying materials. The store may not have exactly what you're looking for, and you may have to improvise. I wound up getting some different parts because my local store didn't have the exact parts I was looking for. This usually appears in the form of not having a threaded fitting, but having a smooth pipe connection, or vice versa. Not a problem, you can figure it out.

Installation Materials

- Long section of 1-1/4" PVC ("drive pipe", connects pump to water supply)
- Garden Hose (male end threads into 3/4" union, supplies pumped water)
- Bricks, blocks, rocks to prop up and anchor pump
- Shower Drain assembly (must be able to attach to 1-1/4" pipe, for attaching pipe to water supply)

Build Materials and Tools

- PVC Primer (I used Oatey Purple Primer)
- PVC Cement (Oatey again, just what they had)
- Teflon Thread Tape
- Hacksaw
- Measuring Tape
- Clamps
- Pocket Knife
- Lab gloves (keeps the chemicals on the pipe and off your hands)
- Bike Pump (to inflate the innertube)

Step 2: Lay Out the Loot

Now that you've bought lots of goodies, lay them out on the table (or floor) so that you can start to see how the pump goes together. See the pictures for a visual on this.

You will have to cut the long sections of pipe into shorter sections to go between each of the fittings. This is discussed more in the next step.

Step 3: Cut Your Connecting Pipe Pieces

You need to connect each of these little units with some pipe, so set about cutting segments off of that stock 1-1/4" pipe with the hacksaw. They don't need to be long, just enough to reach all the way into each fitting, maybe with some space between. But not much!

Once these pieces are all cut, take your knife (or some sand paper) and try to smooth the inside edge of the pipe. Get all the burr off, clean it up, give it a nice bevel or rounded edge. The idea here is to make these as smooth as possible, to reduce the likelihood of cracks developing with the repeated pressure waves that occur inside the pipe. Clean up both ends, and make pieces to join all of the 1-1/4" fittings.

While you're at it, you might as well clean up the edges on the other sections of pipe, though it will be less critical for the other parts. Now that you've got all the connecting segments, you can actually test fit the first part of the pump together, just for fun.

Don't worry if the pipes seem rather tight when you're test fitting everything. The primer and cement help them go together when you do the real assembly.

Step 4: Fun With Chemicals

Grab your lab gloves, a clamp, primer, cement, two fittings and their connecting piece of pipe. Then head to a well ventilated space, because the primer and cement aren't precisely aromatherapy. At least not the good kind.

For those of you who haven't built things from PVC in the past, it isn't terribly difficult. The primer serves to clean off the PVC a little bit and gets it ready to really bond with the cement. The cement keeps everything together.

Most PVC chemical bottles have caps with little brushes attached to them. Take the cap off the primer, and carefully coat the outside face of the pipe, with a band about 2" wide beginning at the end. Take care not to drip the primer on anything that you don't want permanently purple. Once the pipe is coated, do the same for the inside of the fitting that you're planning on cementing up. Close up the primer bottle.

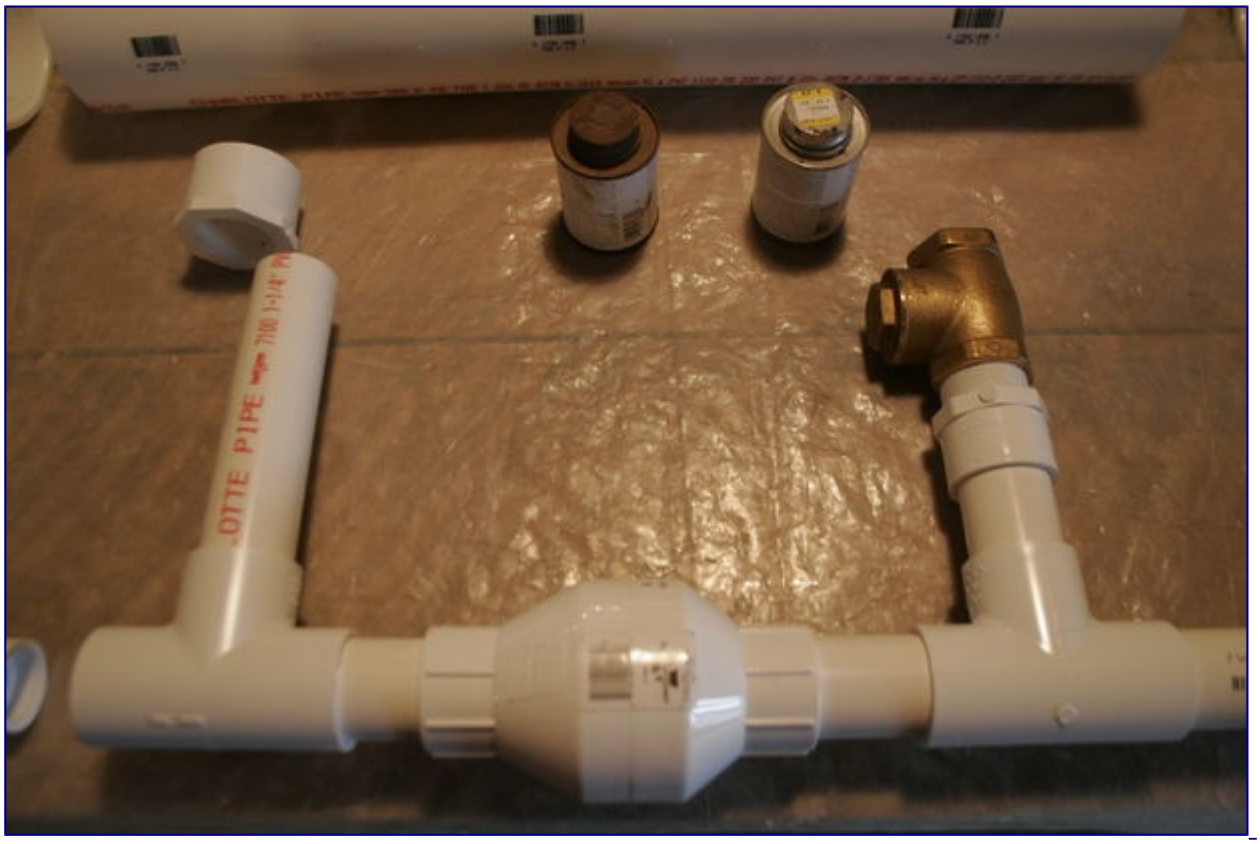
Open up the cement bottle, which should also have a little brush in it. With this brush, go over the areas that you painted with the primer. Don't rush, but you do want to get the pipes together before the cement dries up. You've got time though, so focus on getting a nice coating of cement on both pieces.

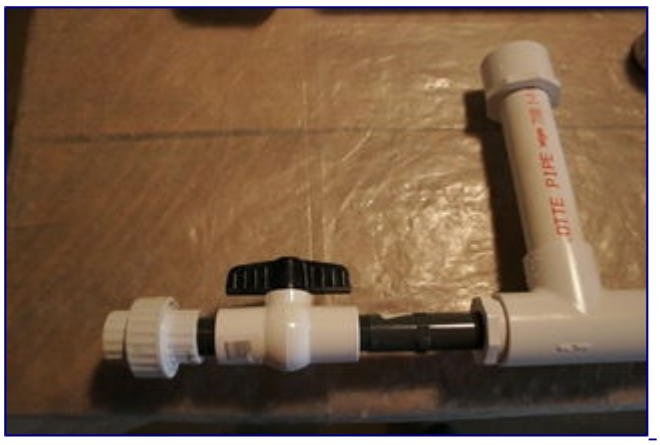
Once you've got cement where you want it (and hopefully only a little where you don't) fit the pipe into the fitting. It should slide in without too much resistance. When working on my pump, I felt that it was best to clamp up each piece after I had assembled it, that way the pipe couldn't slip back at all. It may not be necessary, but I figure it helps.

Most of the pieces go together in a fairly self-explanatory way, but there are a few things to note: on the **spring check valve** there is an arrow, and you will want this to point **toward** the main tee that will have the 4" pipe (air chamber) on it. This allows water to pass through toward the main tee, which you want. With the brass **swing check valve**, the arrow should point **down** toward the tee, and the main line of pipe.

On to the next step for order of assembly!

Step 5: Piece by Piece (Main Line)





I began at one end of the pump, with the 1-1/4" valve to the 1-1/4" union. You can choose to start with other pieces, but I found that setting up the main line gave me something easy to clamp up. After the 1-1/4" to 3/4" bushing is on this tee, you can glue up the end assembly separately, and then connect it to the main assembly with the threaded 3/4" pipe.

When connecting the threaded sections, make sure to wrap some teflon tape around the threads. This will help the operation along and prevent leaks at these joints.

Step 6: Piece by Piece (Pressure Chamber)

Now you need to put together the pressure chamber. Gather up your big pipe section, cap, adapter, bike tube, and bike pump. Using the pump, partially inflate the bike tube. Don't pump it up all the way, just enough that the tube is squishy. We need the air in the pressure chamber to act like a spring.

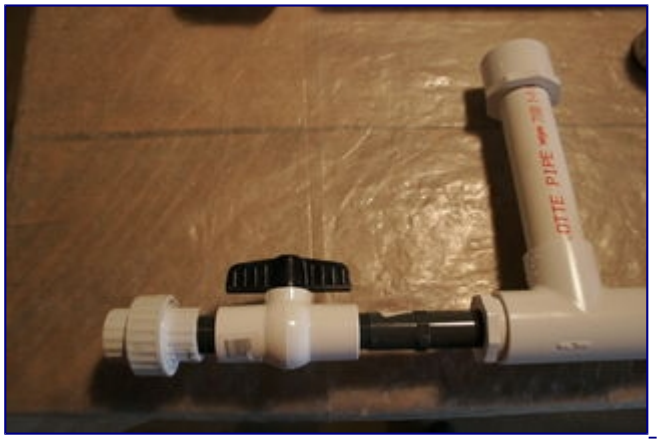
The bike tube prevents the pressure chamber from becoming waterlogged during operation. Air dissolves into water. It does so more readily at high pressure. (This is related to how commercially produced soft drinks are carbonated) The bike tube sequesters some of the air from ever contacting the water (in theory), and prevents **all** of the air from being carried out of the pressure chamber.

Stuff the bike tube down into the big pipe, a la image two. After this, cement on both ends, and clamp that sucker up. Once that's dried up, go ahead and glue this whole assembly to the pipe coming from the main tee.

Note on possible improvements / modifications:
Some may choose to omit the bike tube, and just drain the pump out every once in a while. That's totally possible. It's also possible to either mount a schrader valve onto the end cap of the pressure chamber to recharge it. Whatever suits your fancy, but this setup worked fine for me so far.

Step 7: Optional Pressure Gauge Assembly


A-741


TEE PIPE

If you want to use the pressure gauge, you will mount that after the main tee. Setup is pretty self explanatory. From top to bottom it goes: Gauge, pipecock, nipple, bushing, tee. Remember to wrap all threaded connections with teflon tape, and make sure you tighten them up well.

Installing this requires cutting the 3/4" x 6" pipe nipple in half, which creates two pieces, threaded on one end and smooth on the other, to go into the bottom arms of the tee. Cement these.

Step 8: The Last Piece (for the Pump Anyway...)

If you haven't done it already, install the brass swing check valve. Make sure that the flapper (I just like calling it that) is hanging down, when the pump is held upright (everything pointing upwards). The whole thing should just thread onto the bushing that you've cemented to the end of a 1-1/4" pipe. Simple enough.

After that, you may break out the flapper dress, cut your hair short, and swing dance the night away celebrating the reckless spirit of the Jazz Age (and completion of your pump). You party animal you.

Step 9: Pump Installation

Show All 7 Items

Now that you've got a rather aggressive looking collection of PVC bits, it's time to make it do something. You'll need to attach the stand pipe (the long section of 1-1/4" pipe) to the 1-1/4" union with cement, and then decide how you want to hook the other end to your water source. My first method was a chopped up milk jug. Honestly, I just wanted to see this thing pump some water.

My later design was to mount a shower drain on the other end of the stand pipe, and fix that to a styrofoam cooler that I had cut a matching hole in. The cooler served as a collector for the pipe, and it all worked pretty well. In more permanent installation (to be completed in the coming spring) I'll attach this shower drain to a board that can be fixed in the higher water supply, and things will be good.

Gather up a garden hose, your stand pipe, and your pump, then drag all of this out to your waterfall or what have you. Bring a friend or two. They help in the setup, and maybe you can win the bet that "you can pump water above the source without electricity, gasoline, diesel, a bicycle, or a bucket while they watch."

At this point you can probably figure it all out on your own, but you'll need to get the water flowing down the stand pipe, which you've connected to the main pump, and then up through the swing check valve. On to the next step for theory of operation, troubleshooting and tuning.

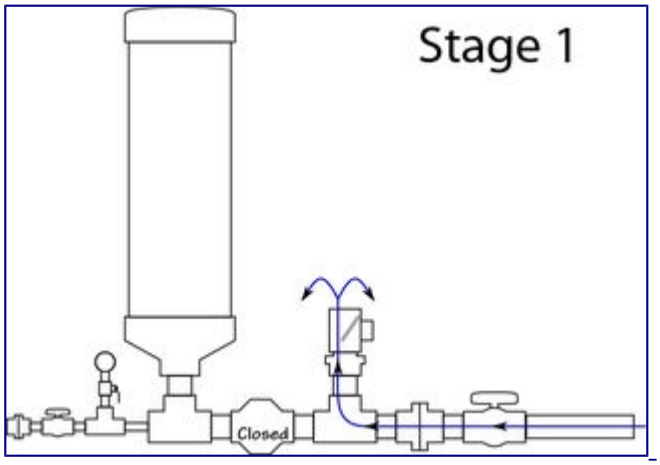
When you install this permanently (or semi-permanently), you'll want to find a good place to anchor it to, probably *not in the stream*. Place it as low as possible, but keep in mind that if the stream were to flood and / or a tree to wash down it, it would take your nice little pump off with it.

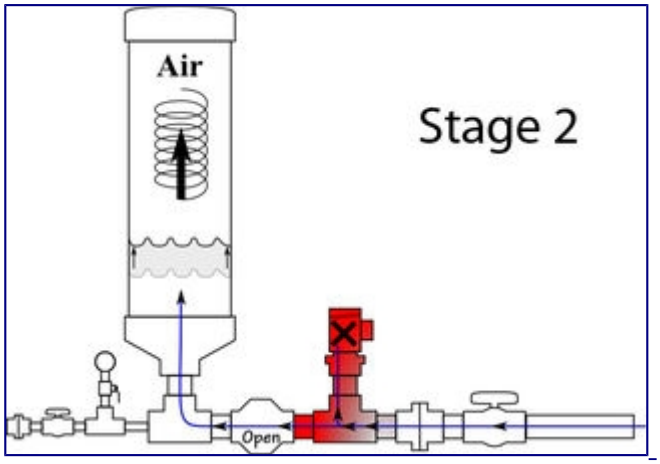
Also, for those in the northern (or far southern) latitudes, you won't want this to be running during the winter. Water could potentially collect inside the pressure chamber and freeze, causing you problems (untimely death of pump). But experiment as you feel fit.

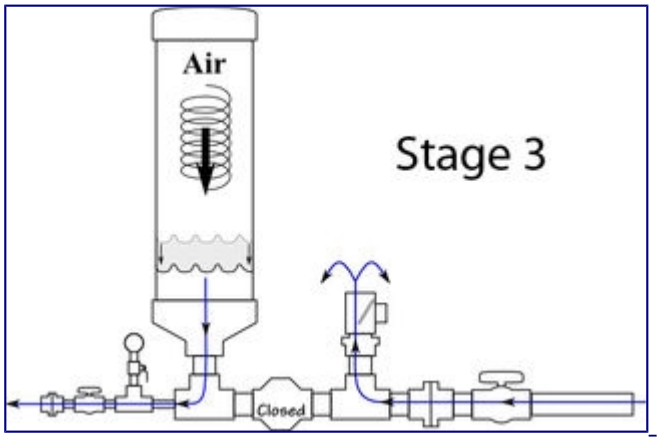
The video here is playable using Quicktime. Presently, you have to save it to your computer, and change the extension (bit after the long strange file name) from **.tmp** to **.3gp**. I'm sorry it's being difficult, maybe someday I'll set it up with an embedded player, but right now I'm short on time. It shows the pump working, with narration by yours truly. Gives you an idea of what it sounds like standing in the water right next to it, and also has a close up of the swing check valve working.

- Hydraulic ram pump.3gp

1. Step 10: Howsitdodat?







So here goes for the operation of the pump.

As the pump cycle begins, water flows down the stand pipe, and up through the swing check valve. Water begins to flow faster and faster around the flapper in the check valve, until friction draws the flapper up, slamming it closed. This causes a pressure spike in the pump body, as the water flowing down the stand pipe at some speed no longer has anywhere to go. This pressure is relieved by some of the water flowing across the spring check valve, over onto the pressure chamber side of the pump. Once past the swing check valve, it cannot return, and has to stay there. When the pressure difference across the spring check valve drops, the valve will close and water will stop flowing through it. The lower pressure will allow the swing check valve to open again, beginning the cycle all over again.

Troubleshooting

So what if this doesn't happen? Well, first things first, check and make sure that it's "on". That is to say, make sure both the 1-1/4" and 3/4" valves are in fact open.

Sometimes water will flow out of the swing check valve, then the valve will slam closed, but nothing will happen. If this occurs, tap on the flapper in the check valve to open it up again, and let the cycle begin again. In theory these pumps need some back pressure (coming from the pressure tank side) to operate, but I've never had any trouble getting mine going with just some basic tapping and fiddling.

Tuning

Now that it's working, can you make it work better? You'll find that there's a maximum height that the pump can deliver water to. Be patient when trying to find this, as it takes a little while for the pump to achieve the pressure required to raise the water up higher and higher. There are formulas that will tell you how high you can theoretically pump water based on the source water head. Feel free to look them up.

Tuning ram pumps mostly involves varying the water velocity that results in the swing check valve closing. A higher water velocity will generate a larger pressure spike, allowing you to pump to greater heights. But it will also cause a slower cycle, so you pump more slowly. If the valve closes at a lower water velocity, it will take less time for the water to reach that velocity, so the pump will cycle faster, and the water pumped faster, but you will not be able to pump as high. So that's the trade off. Keep in mind though, that this will work without interference 24 hours a day, so combining it with a holding tank, you can get a decent supply of water built up.

To tune this specific design, you take advantage of how gravity acts on the flapper. When the check valve is pointing straight up in the air, the full force of gravity holds the flapper down, so the water must flow past the flapper faster to generate enough drag to raise the full weight of the flapper. By rotating the pump about the main line, you put the flapper's degree of freedom at an angle to the force of gravity, so that less drag is required to move the flapper. You could work out all of this fairly easily with a bit of trig, but I feel it would serve you little use out in the field. Just play around with it, you should find a position that works well for your application.

No Power?

Well, no. This pump derives its power from the potential energy of the water uphill, and by wasting (not in a bad sense) the majority of the water that flows through the stand pipe. It only pumps a small fraction of the water that actually travels down that pipe. But that's fine if you have a stream already flowing down a hillside. Before, you weren't doing anything with all that potential / kinetic energy. Now you are. Hooray for you!