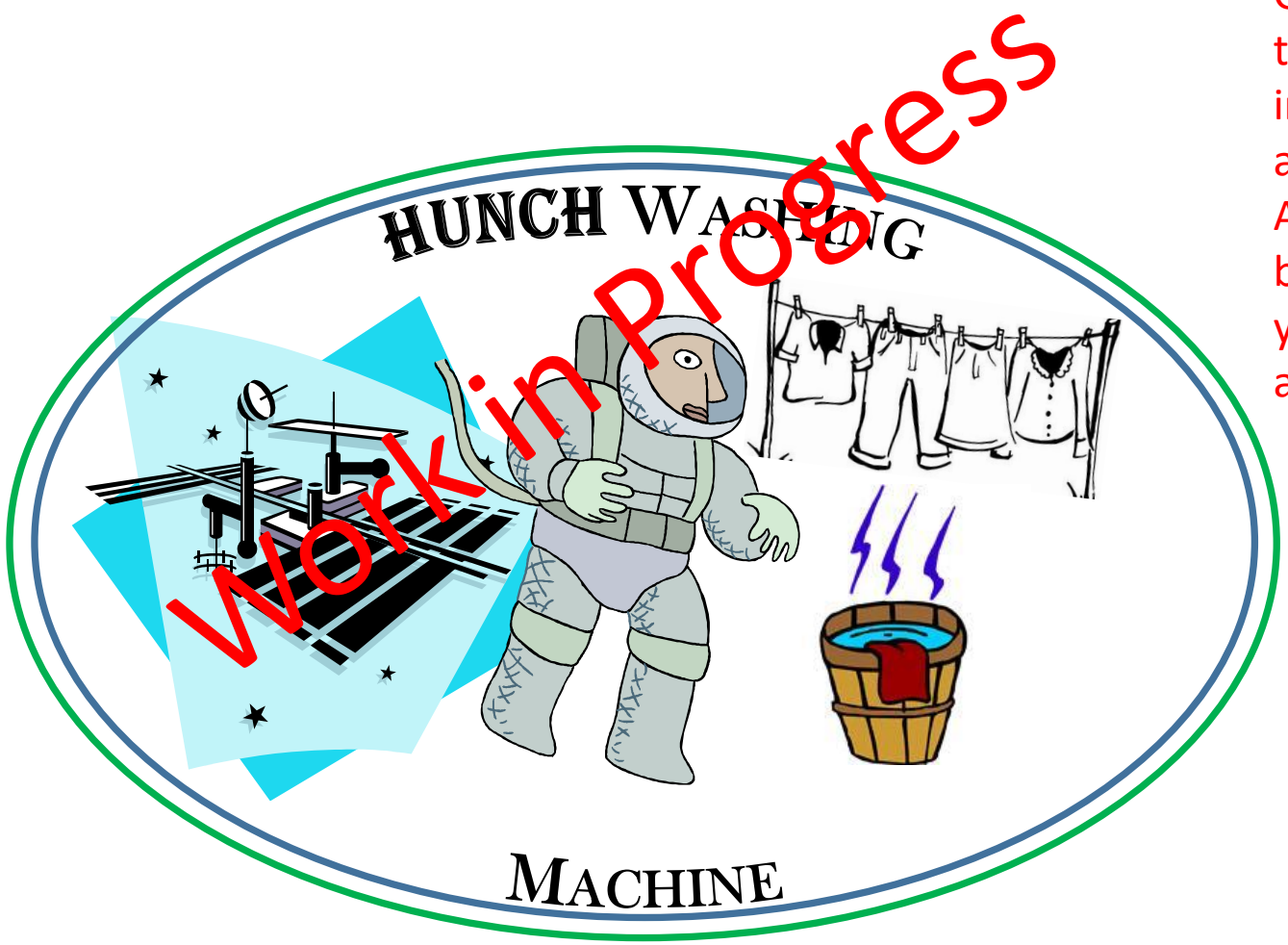
HUNCH Washing Machine

Glenn Johnson



Glenn Johnson is working with the HUNCH Team to make improvements on this project and will be mostly done by August 1st 2026. Changes will be made during the school year as students ask questions and need clarifications.

I used clip art for this hardware patch. How could you make it better?

The Problem:

- The International Space Station has no way of cleaning clothes. Instead of flying up a set of clothes for every day, astronauts have to wear their clothes for multiple days to minimize their clothing needs. Each crew member only gets 2.5 CTBs of volume (about the same as 2 small suitcases) and a total of 66.9 lbs per person for all their personal items.
- https://www.tiktok.com/@curiosityinspace/video/7290214587834649888
- This may sound difficult for most people, but the astronauts have few complaints because they don't dirty their clothes the same as they do on the ground—they stay "clean" longer. Also, the cost for shipping up and burning clothing may sound expensive but the volume a washing machine would take up instead of a science experiment is significant and would be a larger cost in lost science. The time the astronauts would spend washing clothes could be used more effectively doing science. So long term usage of a washing machine on the ISS is not needed, however the ISS is the right place to test a washing machine. Any mission that goes beyond Earth orbit and won't be resupplied on a regular basis--like going to Mars and even to the Moon--will need to be able to clean and reuse their clothes to save on mass and stowage space.
- Because of zero gravity, a standard washing machine will not work on the Space Station.
  - Standard washing machines are way too big for the available space.
  - Water needs to be recycled
  - The recycling of water requires significant power and time—don't use too much at a time.
  - Water acts differently in zero-g—it can't be wrung out by hand and just evaporation of the dirty water will leave all the dirt in the clothes.
  - Some kinds of soaps or detergents can damage equipment in the water recycling system or other equipment
  - Spin cycles or agitation cycles would affect the whole vehicle (spin or vibrate) and all the experiments that depend on micro-gravity
  - Electric clothes dryers remove water by evaporation but don't do much related to cleaning.
  - Electric clothes dryers are very power hungry because of the electricity needed to heat the elements to high temperatures. This also would put significant amount of heat into the Space Station.

Requirements for the ISS Washing machine:

Objective:

Design, build and test a washing system that can take in a dirty, medium sized polo shirt, inject it with water, agitate the shirt, remove the dirty water and then return the now damp polo shirt to be hung out to dry.

Specifics to help:

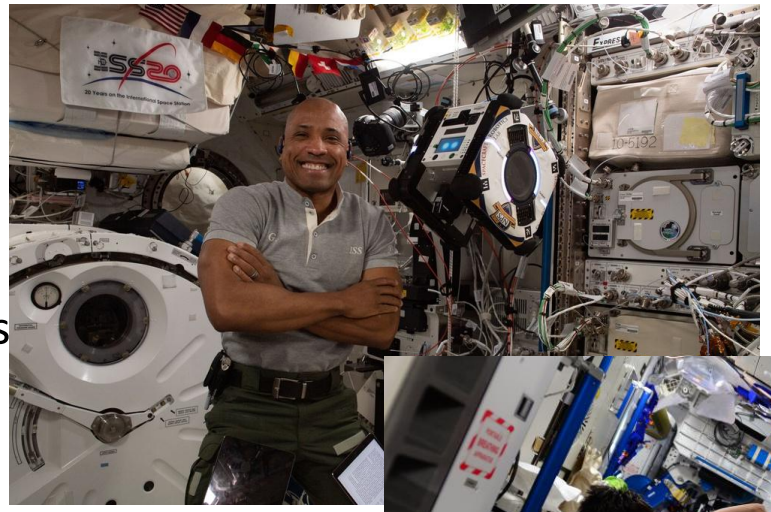
- Receives water from the Potable Water system at about 71F and 15 psi
- Polo shirt soiled with--sweat and salt crystals, 3 smudges of siracha sauce and 3 smudges of mustard
- Returns a shirt that is damp—not dripping wet
- Can be hooked up to a laptop for diagnosis if there is a problem
- Can be hand crank if you don't have strong enough motors for your prototype.
- Fits in an ISS Double Locker that fits in an EXPRESS rack
- Contains the water in a zero-g environment

Goals:

- Easy to use.
- Low power consumption
- Low maintenance
- insignificant damage to shirt after 50 washes
- Doesn't take much astronaut time to load and remove shirt. This needs to be mostly automatic.
- Minimize amount of vibration that could be transferred into the Space Station
- Can be scaled later to handle most clothing items from socks to a pair of pants

Clothing background information on the ISS

- One crew member averages 15 days per shirt. That still requires 12 shirts for a 180 day mission. Multiply that by pants, shorts, socks, underwear… for 7 people. For the few days when it is fresh, a shirt may be used for conducting an interview. A day or two later, now that it is getting dirty, it gets used while working on repairs, then it might get used as a workout shirt. Once it is fully dirty, the shirt is placed in the trash to be thrown away. They may wear a few different shirts throughout the day to help keep clothes more fresh. To be fair, clothes don't get as dirty on orbit as they do when at home since they don't go outside and the amount of dirt on the Space Station is fairly small. But still dirty clothes can be uncomfortable as the clothes get closer to the maximum number of days. After use, nearly all the clothes will be thrown away by placing them in one of the leaving supply ships and they burn up in the atmosphere with the rest of the trash.
- Another issue is that dirty clothes are smelly even while in the trash. Imagine having lots of dirty clothes stuffed in bags waiting for the supply ship to be emptied of cargo so they can fill it up with the trash. Dirty clothes can increase the stink in the Space Station.
- There have been a few examples of crew washing their wrist bands or running harnesses in a Ziploc bag of water but this is very time consuming and managing the dirty water afterwards can be difficult. Where does it go, how is it moved from one place to the other in zero-g? Very little research has been done on orbit for washing clothing and disposing of the dirty water. The water needs to be cleaned and reused.



Cleaning Clothes

The key to cleaning clothes is in the many potential methods of removing the surface and dissolved dirt and materials.

- Using air, like blowing air through the clothes or using a vacuum cleaner to suck dirt out, could remove some of the materials that are loosely attached to the surface of the cloth but it won't remove things like the salt crystals from sweat or skin cells embedded in the fibers. Nor does it remove bacteria that is eating the different materials left by the person.
- Dry Cleaning isn't actually dry. It uses different types of cleaning fluids than water. These fluids are not anything that could be used on the ISS. There is a lot to learn about dry cleaning. I'll let you look it up.
- If water is injected into a dirty shirt, the water dissolves much of the salts and dirt that is in the shirt. The water can soften dried food stains and lift the food out of the fibers.
    - If the shirt is allowed to dry with all the water still in it, the salts and dirt remain in the shirt. The dirt may have been rearranged in its location, but the shirt still has all the same dirt—nothing accomplished.
    - If the shirt is squeezed or wrung out, any dirty water that comes off means the shirt is cleaner since less dirt will be on the shirt when it dries.
    - Any dirty water that is removed from the shirt, means the shirt is cleaner than before.
    - The more water used, the cleaner the shirt. Imagine leaving a dirty shirt in Niagara Falls. So much water is flowing by and only has to take a little bit of dirt out of it at a time. Because there is a lot of water, the shirt gets clean. We won't get that much water, more like a few cups of water.
- Electric clothes dryers remove water by evaporation but don't do much related to cleaning. Any dirty water remaining in the cloth, leaves the dirt when dry. They may be able to kill bacteria if the temperature gets high enough in the dry clothes but that seems unlikely for most bacteria.
- Electric dryers are very power hungry because of the electricity needed to heat the elements to high temperatures.

Options for process?

Make a Dirty Shirt—Take your clean shirt and allow very salty water to dry into the shirt evenly, smudge 3 stripes of mustard and 3 stripes of siracha sauce into the cloth in different locations so you can see how evenly the washing happens.

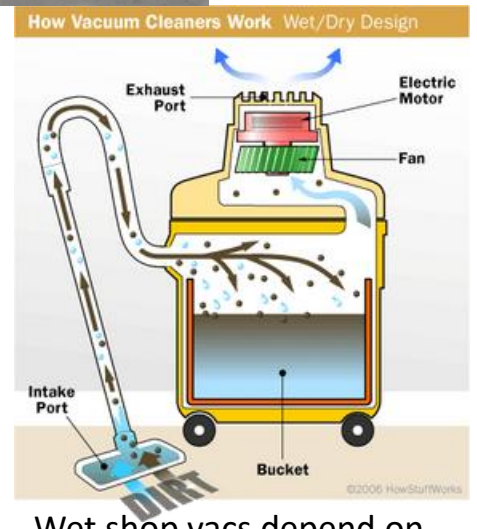
How to automate?

- Chamber—where does the shirt go into to contain the water?
- Wet the shirt—inject clean, room temperature water evenly so all cloth is exposed to the water for a similar amount of time.
- Allow to soak for a short time to loosen food items(1 min. or so?)
- Agitate the wet shirt (you decide)
  - Compression—piston, rollers (loose or tight, smooth or bumpy)
  - Wringing—twisting back and forth loosely
  - Water jets—injecting water into and out of the chamber repeatedly
  - Another idea?
- First stage to Remove dirty water (you decide)
  - Compression—piston, rollers (tight)
  - Wringing—twisting back and forth tighter
  - Compression—atmospheric compression--vacuum pump
  - Another idea?
- Second stage to Remove the dirty water—shop vac (big opening, long thin opening, squeegee)
- Dry the shirt—hang it out to dry in the open air.

How clean do you think it is?

Do you have a good way to measure its cleanliness?

Other options?



Wet shop vacs depend on gravity for separation but it will work for our testing.

Make it simple

Item of Clothing

Part of the difficulty with a washing machine is that all of these components need to be sized so that they can handle a variety of clothes from a pair of pants down to a pair of socks---we are not doing that yet. To be realistic for ourselves, our current goal is to be able to demonstrate your device with only a **medium sized polo shirt**—you choose the color. This will give a realistic test for your team to begin with. Later we will develop the ability to wash more items.

Wash Cycle

Washing a shirt is easy on Earth but much more difficult in zero-gravity. HUNCH is looking for students to taking the first step to washing a shirt. You are going to demonstrate the zero-g equivalent of washing your shirt in the sink, wringing it out, and hanging it up to dry. A simple sink washing would be similar to making your shirt something like 70 to 80% cleaner—a good start.

Although this is easy at home, this is difficult in micro gravity because the water can float everywhere and get into electronics or allow mold growth or even get into astronaut eyes, nose and mouth.

This needs to be kept simple so it works and isn't too complicated.

Soap

The majority of the cleaning is done by water. We all know that washing with soap will make a shirt cleaner. What kind of soap and how much to add is a completely different discussion and is not necessary at this time. Later, once we've demonstrated how to get the clean water in and the dirty water out, we will add soap and make the shirt cleaner. There is nothing complicated about adding soap to water for this project so **don't bother with soap.**

Clothes Drier

The Space Station has lots of fans that blow air across cold plates to cool it off. The moisture in the warm air condenses on the cold plates and leaves the now cooled air drier. The droplets of water that form on the plates are collected and are recycled into clean water. The circulation of the air past the cold plates keeps the humidity in the Station at about 40%. The astronauts typically dry their clothes by hanging them in the module and let the airflow remove the moisture and the system recycles the water to be used again. This is similar to the old style of using a clothes line. The astronauts are mostly satisfied with drying their clothes like this. For the time being, **we don't need to concern ourselves with drying the clothes**—just washing them.

ISS Double Locker size

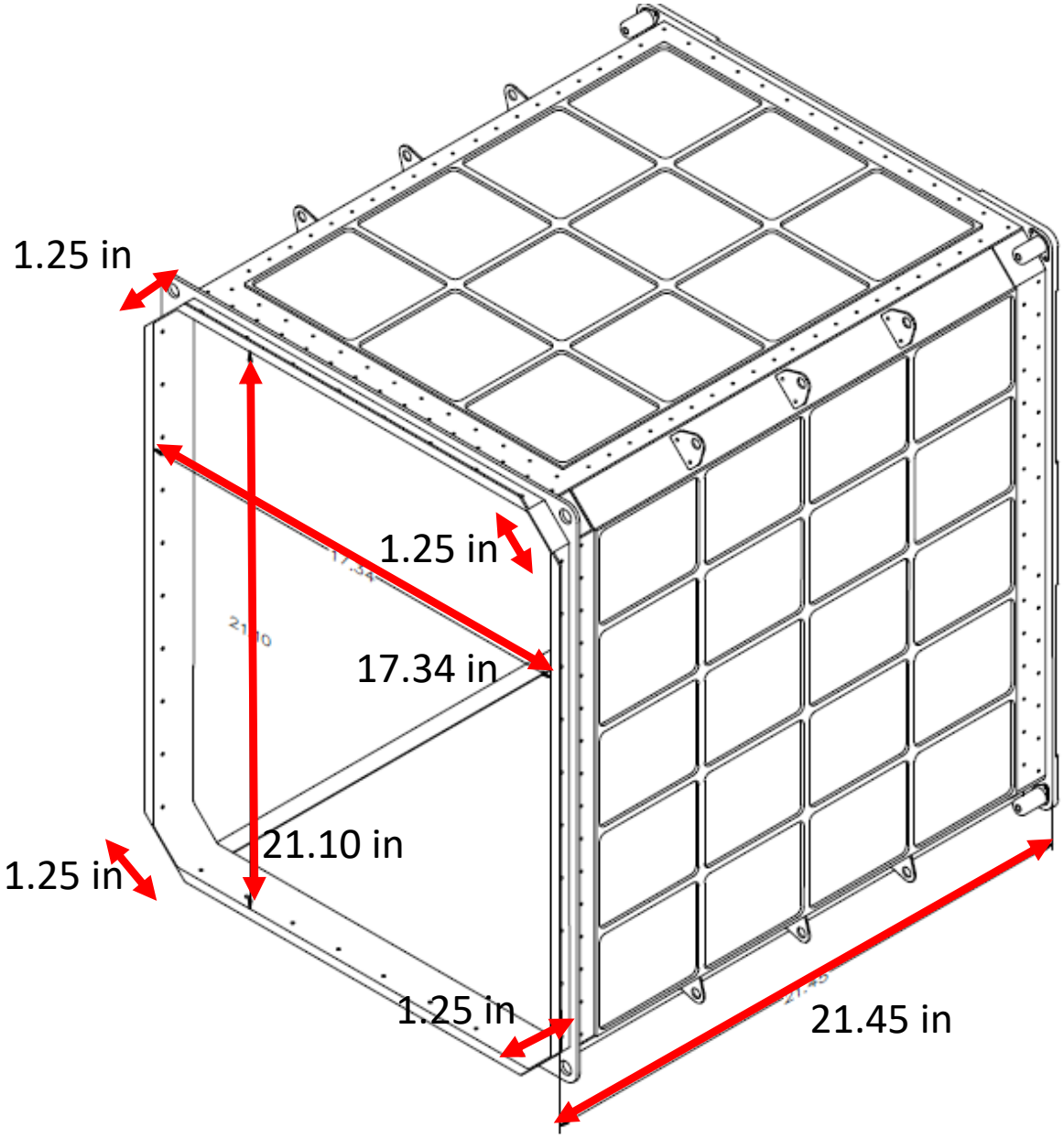
- Don’t expect that astronauts would be able to wash a big load of laundry like we do on the ground. There is no way that the Space Station could have as big of a washing machine as what is used at home. Crew members will still be on a restricted amount of clothing. But it would be possible to wash one or two pieces of clothing at a time to keep the total number of clothes to be launched to a minimum. To keep a washing machine to a size that is reasonable for the needs of the ISS and the research requirements, a washing machine should fit within an ISS Double Locker. This is a tough constraint as it is a small compartment for all this hardware to fit in.
- Because of the potential for snags as the clothing is being washed and the potential for dirty water or lint to clog up the water flow, the inside will need to be accessible to the crew for maintenance purposes. This means that the washing machine will need to be set up as a drawer that will pull out of the Double Locker making most of the components easy to access. This would be similar to how a file cabinet has drawers allowing the front face to be where the clothes are accepted and returned to the person. The inside components would be accessible when the drawer was opened.

The Potable Water Dispenser is how the crew fills food and drink bags with water. It is contained within an ISS Double Locker.

Imagine it kind of like a file cabinet drawer.

The main components are in an inner drawer that slides out on rails allowing for maintenance. The washing machine could be done similarly.

Inside Dimensions of an ISS Double Locker



These two single lockers could be replaced with a Double Locker

EXPRESS rack with 8 single ISS Lockers

Your creativity:

- There is no requirement that electric motors are used to show your idea—most motors would move too fast and need to be geared down to demonstrate most concepts for this. Hand crank works fine for all the roller demonstrations but you should plan to show where and how the motor will fit into the system. Not all steps will need a motor. It may be possible to use one motor for the whole system but that will require gearing and possibly belt connections that are not necessary at this time.
- For the control system it will be necessary to have some electronics (motors and lights)to demonstrate your system—you need to show that your panel and software is able to control motors and lights. You will need to understand the needs of each of the components of the washing machine to model up how the system will work as a whole. Plan on using small, cheap motors and LEDs for demonstrations. Organize the components so it is easy to see the flow.

Water containment

- Putting the shirt into a plastic bag with water contains the water but how many times can the bag be used before ripping, tearing or smelling more than the shirt? We would like to not be sending lots of plastic bags to Mars if possible.
- Pliable silicon? These are available as alternatives to sandwich bags.
- Putting the shirt in a bottle will probably leave some air in the container. It could be difficult to separate a mixture of air and water depending what you do with the water. How do you get the shirt into and out of the bottle?

Hydrating the shirt—getting the shirt wet enough to clean without using too much of a valuable commodity

- Spraying--in micro gravity, water droplets are just as likely to bounce off a shirt as to get absorbed by the shirt.
- Plan on injecting the water slowly.
- Try to use as little water as possible. Quantify how much your team uses. Part of the difficulty is that if you don't remove much dirty water, you are not cleaning the shirt. How much water is needed to get it "reasonably clean"? The more water used, the easier it is to clean but because of limited water on the vehicle, we need to conserve the volume of water used as much as reasonable. It seems like it takes at least 350ml to get the whole shirt wet but it doesn't wring out. Can you use as little at 500ml to clean?
- Soak time--Letting the shirt soak for a little while will allow the sweat, salt crystals, food particles,… to dissolve in the water.

Watch how water behaves when washing long hair.

- https://www.tiktok.com/@europeanspaceagency/video/7647553821593406752

The white covers behind her were made by HUNCH high school students.

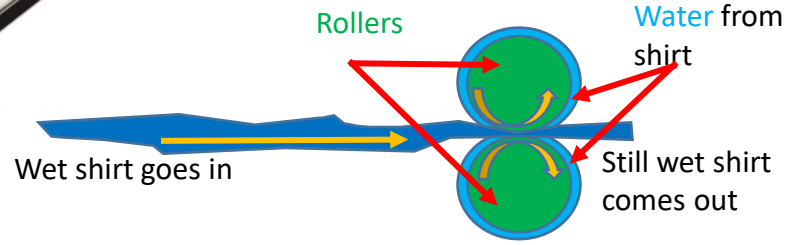
Automating agitation in zero-g is easier said than done

Agitate shirt—actions that help separate soils and food particulates move out of the fibers and into the water

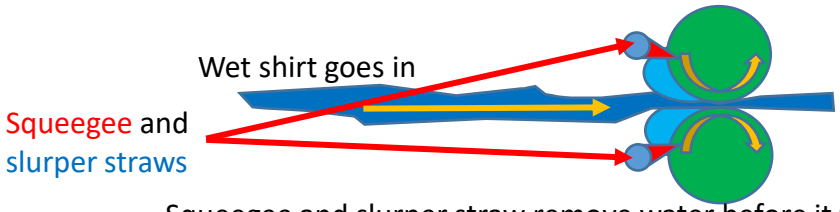
- in older times, a person might beat the clothes on a rock,
- swish the shirt around in a bucket and wring it out a few times.
- On earth, washing machines agitate the clothes by swirling the water and clothes
- they might tumble the clothes in a front loader, Several of these things depend on gravity and won't work.
- It is important that agitation methods not affect the rest of the vehicle—fast spinning, violent shaking

Remove dirty water from shirt

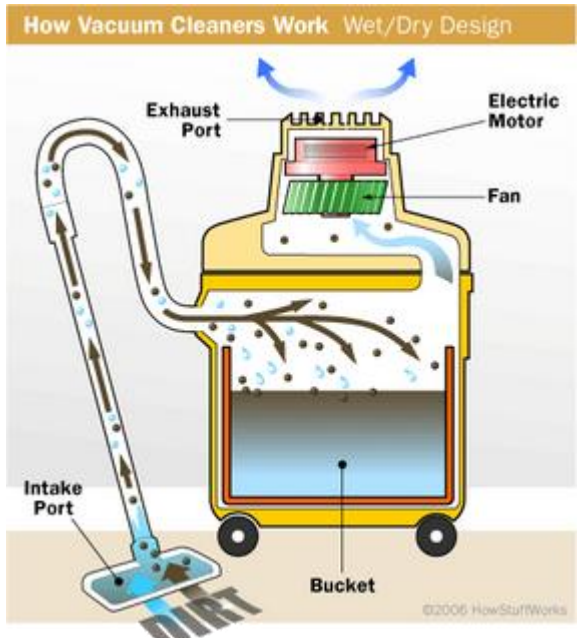
- Wringing by hand will squeeze the water out of the cloth but without gravity, the water will stay clinging to the cloth and be reabsorbed when the wringing stops. What absorbs or sucks up the water before wringing stops?
- Older washing machines used rollers to squeeze the water out but gravity is what removes the water from the rollers. How do you remove the water from the rollers before it re-wets the clothes on the other side?
- A washing machine on Earth will spin a drum to remove the water. In zero-g, this will spin the spacecraft in the opposite direction—bad idea. The clothing might also not be evenly distributed in the drum and could vibrate all the experiments on the vehicle—bad idea.
- Using a vacuum to suck the water off the cloth would work but a wet/dry shop vac depends on gravity to separate the water from the air flow



In zero-g, the water will stay on the roller and travel around to re-wet the clothing on the back side.



Squeegee and slurper straw remove water before it travels to the other side of roller.



Controls

- Try to make it as automated as possible so the crew can put the shirt in, your washer does its thing (take several minutes—5 to 15 min), come back and hang the shirt out to dry
- Keep the controls simple
- The controls would probably look something like:
    1. Control valve for water being injected into the shirt
    2. Control motor speeds for agitating shirt
    3. Control motors for squeezing shirt to remove water
    4. Turning on fan to remove water from shirt
- We will assume that the removed water is sent through the toilet to be recycled.