

Tertill

Garden Weeding Robot

Owner's Manual

Model T1



Dear Backer/Tertill Owner,

Thank you. Tertill exists because of you. Your interest, support, and patience made it possible for the team at Franklin to turn our dream into reality. We are grateful. Now Tertill can begin to reduce herbicide use, increase home food production, and ease the lives of gardeners everywhere. The impact of your contribution will reverberate far beyond your home garden!

But we're not done yet. Tertill is only just hatched and has much to learn. We at Franklin have done our best to think through all the situations Tertill might face, program responses, and test extensively. But as Tertill makes its way into the world, its cumulative hours of use will far exceed the time we've spent testing. Tertills in the field will discover situations and problems we haven't foreseen.

That's where you come in. We need your help to make Tertill better. If your Tertill does something unexpected, if it gets stuck or does anything you'd rather it wouldn't, please tell us. You can email a description of your observations and optionally add photos and (brief) videos to: support@franklinrobotics.com. We will share improvements we make to Tertill's software.

Thanks again for your help and ongoing support!

Rory MacKean
CEO/Co-Founder
Franklin Robotics



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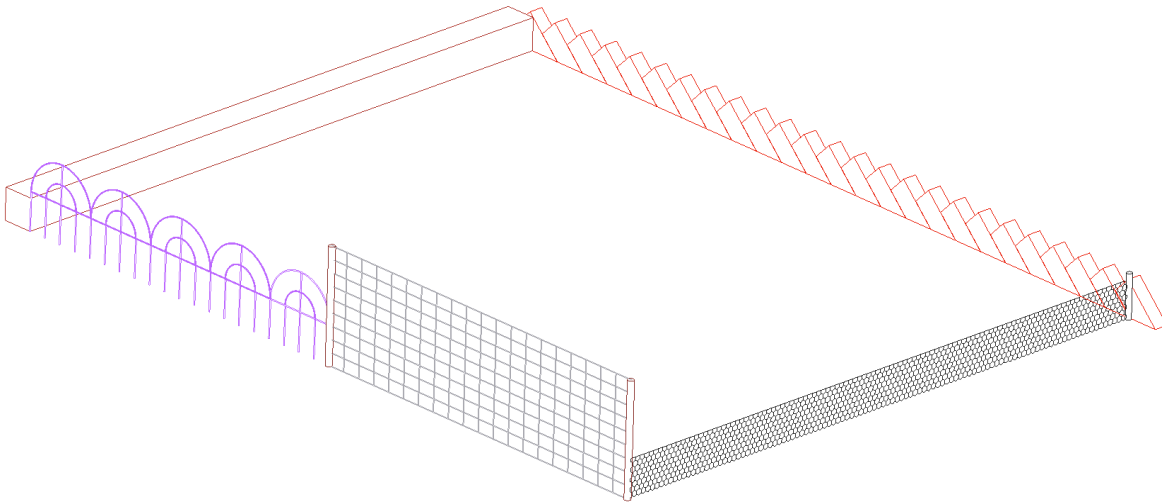
Quick Start

Follow these simple steps to quickly put Tertill to work weeding your garden.

Unpack

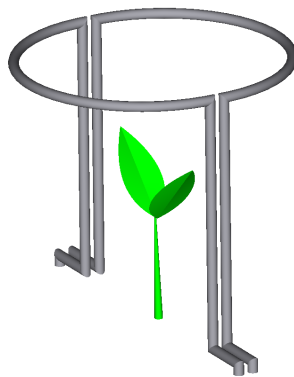
Remove Tertill, the plant collars, wrench, and spare whackers from the shipping box.

Establish boundary



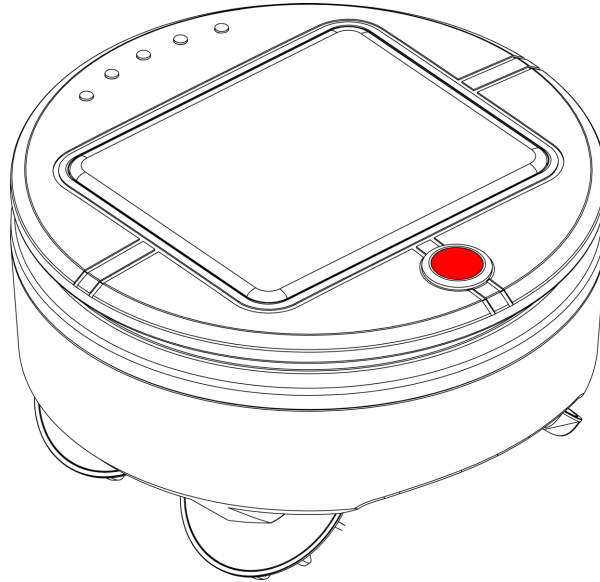
Make sure that a continuous barrier at least 3" (7.5 cm) tall surrounds your garden.

Mark small plants



Place plant collars around small or delicate plants—when in doubt, use a collar.

Activate



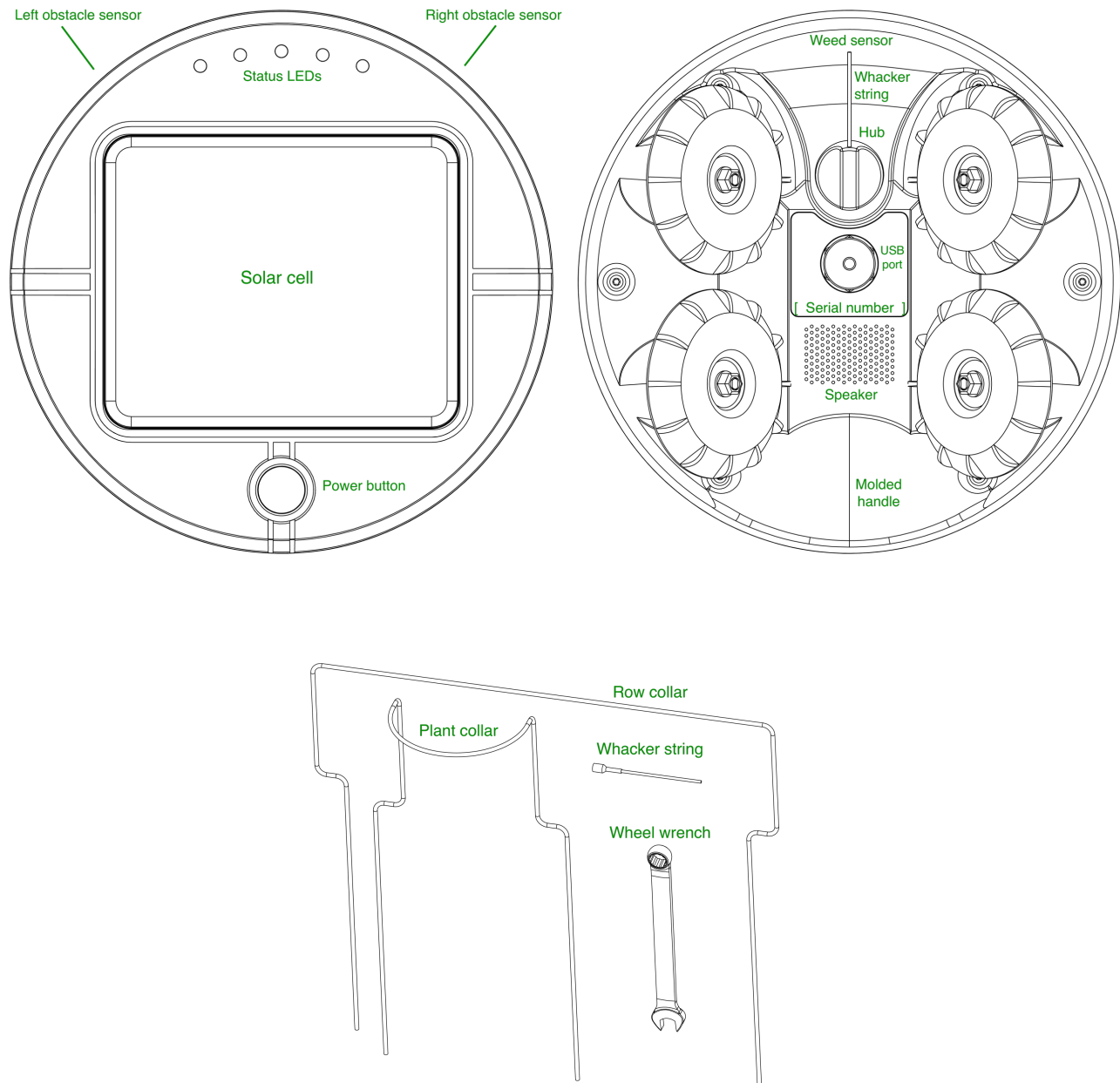
Put Tertill on the ground in the garden. Press and release the power button (red in the drawing). After a few seconds the status LEDs will display a sweeping green pattern. Press the power button again. The display will change to a green, outside-to-center pattern. After another few seconds Tertill will begin to patrol for weeds.

If Tertill does not light the LEDs or does not begin to move, it needs to be charged. Either leave it in direct sunlight for an hour or more or use the USB cable to charge the battery (see the USB charging section, page 14). Then press the button again to start the process.

Garden

Now you are free to do the gardening tasks you enjoy. Tertill will take care of the weeds.

Tertill Terms



Power button – Turns Tertill on and tells Tertill to patrol.

LEDs – Five colored LEDs give you information about the robot.

Solar Cell – Provides Tertill's power.

Molded handle – Pick up Tertill with your thumb on top and to the side of the button and your fingers in the handle depression.

Speaker – Tertill plays tones through the speaker to announce its status and intentions.

Extreme camber wheels – Tertill's wheels are designed to help it move about the garden without tipping over or getting stuck. The wheels also damage sprouting weeds before they can emerge.

USB charging port – Supplemental battery charging port (no data connection)

Serial number – The unique serial number of your robot

Weed sensor – When a weed comes near the sensor Tertill activates its whacker

Whacker string – Spinning trimmer string cuts weeds before they grow

Whacker hub – Holds the replaceable whacker string.

Obstacle sensors – Sensors just inside the robot shell detect plants, wooden barriers, metal fences, and so on.

IMU – (Internal) Inside the robot a six-axis Inertial Measurement Unit detects the robot's tilt and spin rate.

Plant collars – Used to tell Tertill that that a particular plant is desired.

Row collars – Used to tell Tertill that that a row of plants is desired.

Spare whacker string – Replace the whacker string when it wears.

Wheel wrench – Use to remove and replace wheels if necessary.

Robotic Weeding

Tertill is single-minded in its pursuit of weeds. It spends 100% of its time in your garden either weeding or collecting energy so it can weed. Come rain or shine your robot will never procrastinate or forget to weed.

But, Tertill doesn't have your senses, dexterity, or brain power—it can't weed the way you do. Tertill follows a different strategy, one that doesn't involve pulling weeds or moving in a grid pattern.

Tertill attacks weeds in two ways. As it moves and turns in the garden the robot's wheels scrub the soil. This damages weed sprouts and can prevent them from emerging. Weeds that do emerge are cut down by the weed whacker. A chopped weed may sprout again but, because Tertill comes back again and again, the weed will eventually run out of stored energy and die.

As it navigates the garden Tertill sometimes hugs fences, collars, and plants and sometimes bounces away from such obstructions. Following this strategy over time the robot visits every reachable part of the garden.

Garden

Tertill needs a couple of features in order to work in your garden. There are also a few things you can do to help it work efficiently.

Boundary

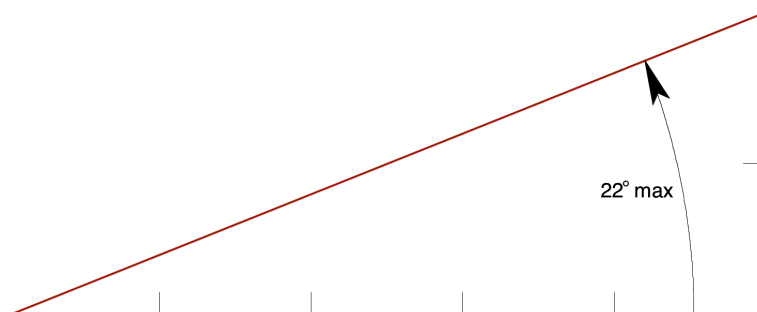
A physical boundary is necessary to keep Tertill from wandering away. The boundary must completely surround the garden and should be at least 3" (7.5 cm) tall. Almost anything will work, common boundaries include:

- Wire fence (chain-link, chicken wire, hardware cloth, etc.)
- Wrought iron fence
- Stockade fence
- Landscaping timber (often used to form raised beds)
- Brick edging
- Supplied row collars

The fence must be of a height such that Tertill can touch it. Tertill performs best if its obstacle sensors can detect the material from which the boundary is made. These sensors do not detect non-conductive materials like plastic. Plastic fences and plastic edging *do* confine Tertill but the robot will take extra time to change direction whenever it encounters such a boundary.

Slopes

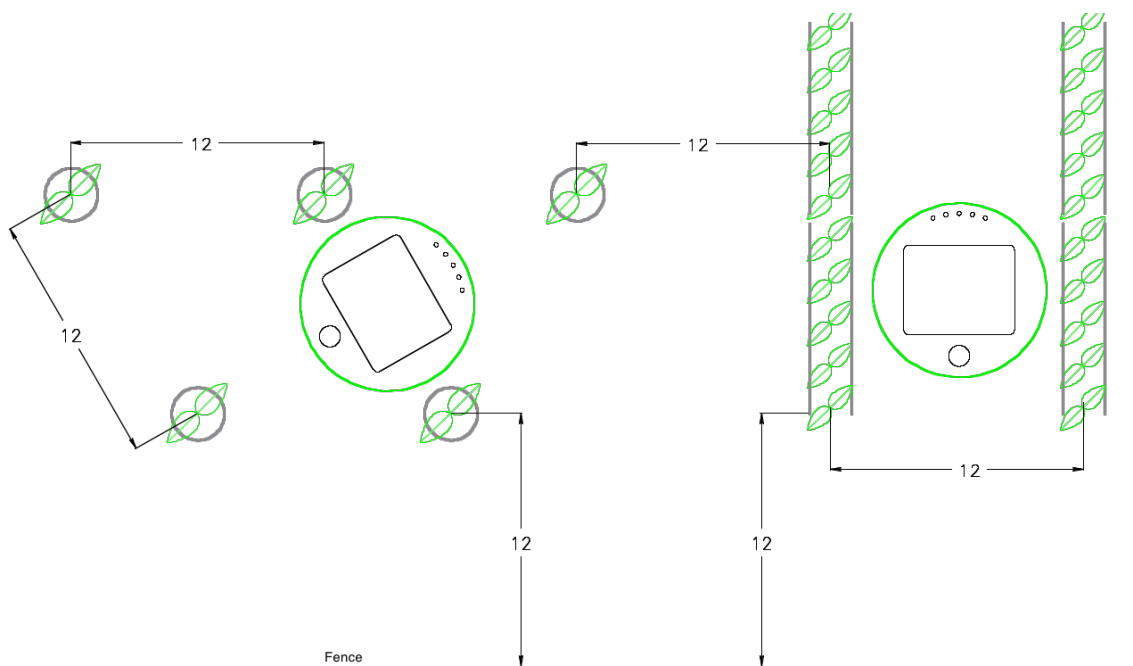
A slope that is too steep can cause Tertill to tumble. For that reason Tertill turns away from any slope steeper than about 22° (40% grade). This corresponds to two units of rise for every five units of run.



Some crops grow best on mounds of soil but avoid building mounds with slopes greater than 22° . Tertill may not visit the top of a mound if the angle is too large.

Spacing

Tertill must have a path to all parts of the garden. If crops are too close together the robot will be unable to pass between them. As shown in the drawing, leave at least 12" (30.5 cm) between plants. Also, leave 12" between any plant and the boundary around the garden. Row crops should also be planted with rows no closer than 12". If plants tend to be bushy, increase the spacing accordingly.



Starting Conditions

Tertill is designed to keep weeds at bay. However, it expects to encounter weeds that are short and just sprouting—as they are in the early spring. If Tertill is introduced later in the season, after weeds have begun to take hold, some may be too tall to be recognized as weeds or too tough for Tertill to cut down. If this is the case, help Tertill get started by manually removing weeds that are too tall (greater than 1 inch or 2.5 cm) or too robust.

Terrain

Tertill works most efficiently when the terrain in your garden is relatively smooth. Tertill will do its best when it encounters rocks, ruts, and holes but any time it spends negotiating such hazards is time it won't spend weeding. We recommend removing rocks as much as possible and raking at the beginning of the season to smooth the garden surface.

A wide variety of surface types are acceptable to Tertill. This includes bare dirt both soft and packed, sand, gravel, bark mulch and other materials commonly used in gardens.

Tertill does *not* sense cliffs. A cliff is any drop off over which Tertill cannot safely drive. A terraced gardens, for example, has cliffs. If your garden contains a cliff it should be blocked off with a fence or the supplied row collars. Otherwise Tertill may tumble.

Operating Tertill

Starting

After ensuring that there is a continuous boundary around your garden and that your small plants are protected by plant collars, you are ready to start Tertill. Place Tertill on the ground then press and release the power button. After a few seconds the LEDs will display a pattern that sweeps from side to side. This pattern means that Tertill is ready and waiting for your authorization to begin patrolling. Press and release the power button again and Tertill will begin to weed. Unless the battery is badly depleted, you can always force Tertill to begin weeding by pressing the power button in this way.

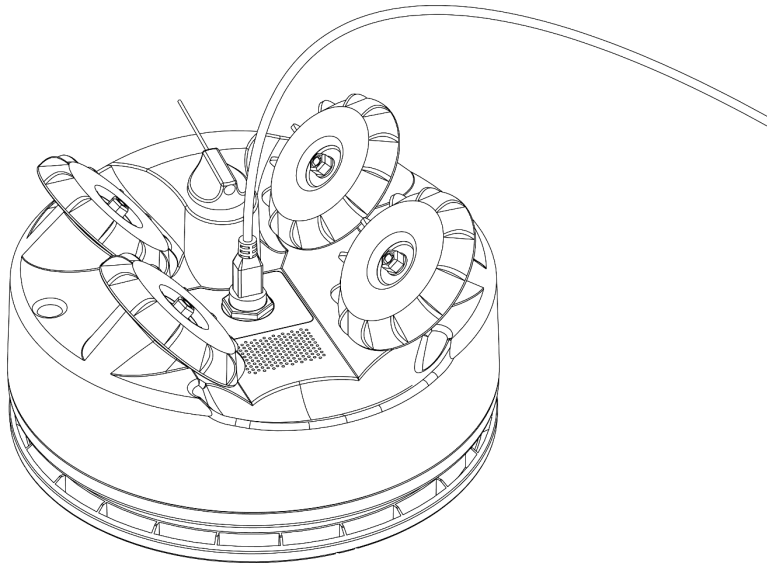
If Tertill does not display the sweeping pattern its battery charge may be too low. There are two remedies for this. Either charge Tertill's batteries by letting it sit in direct sun for an hour or more or provide supplemental charging via the USB connection, see below.

Stopping

You can stop Tertill by pressing and holding the power button (about 10 seconds). If Tertill is patrolling when you want it to stop you can also pick it up by the handle and turn it upside down. Do not pick Tertill up from the front. It may mistake your hand for a weed and act accordingly.

Caution: Do not remove Tertill from the garden without pressing and holding the button as described. Otherwise it may wake up and begin patrolling in a place that is not safe, e.g. on a table top.

The actions described cause Tertill to enter Hold mode. It will not leave Hold mode and begin patrolling again until it receives authorization to do so, i.e. you must press the power button. This ensures that Tertill will only start weeding when you intend it to do so. Always make sure that Tertill is stopped by following the described procedure before you remove it from the garden.



USB charging

In normal operation Tertill gets all the power it needs from the sun. However, it is possible to charge Tertill's battery using the USB charging port on the robot's underside. To use this option: turn Tertill upside down, remove the screw-on waterproof port cap, and insert a micro-USB connector. Your USB power supply should be capable of supplying the 350 mA that Tertill needs to charge.

When done, remove the USB cable and reattach the waterproof port cap. Failing to reattach the cap may allow water to enter the robot.

Note that the bottom of Tertill is likely to be dirty. Take care not let dirt get into the USB charging port. If the bottom is muddy, rinse with water and dry with a paper towel before removing the port cap. If Tertill is dusty, wipe with a cloth or paper towel before opening. It is important to keep the bulkhead connector and the screw-on port cap clean so that they keep water sealed out.

Robot Health

Battery		Wheels	Whacker	Object sensors	Temperature
Normal	Normal	Normal	Normal	Normal	Normal
Needs to charge	Slow, check for debris	Fast/slow check string	Check shell		
	Jammed, clear debris	Jammed, clear debris		Too hot	

Each time Tertill is about to begin patrolling—either because you press the button or the robot decides to go—the LEDs display the health of the robot's systems. As shown in the drawing, from left to right the LEDs correspond to the battery, drive wheels, whacker, object sensors (both obstacle and weed sensors), and temperature.

In all systems green indicates normal operation. Yellow and red mean different things depending on the system.

- Battery – Yellow means the robot needs to charge but you can command it to run for a short time.
- Wheels – Yellow means one or more wheels are turning slowly. Check to see what is impeding the wheel. Red means that one or more wheels cannot turn at all. Remove dirt or debris that is restraining the wheel.
- Whacker – Yellow shows that the whacker is turning too fast (the string may be too short) or too slow (debris may be wrapped around the shaft). Replace the string or remove debris. Red means the whacker does not turn at all. Remove debris to free the whacker. When you flick the whacker with your finger it should spin around several times.
- Object sensors – Yellow means a weak or unchanging signal. Check the front, sides, and bottom of the robot. A large leaf or other debris that has attached itself to the chassis can prevent the sensors from working properly.
- Temperature – If the temperature of the robot, battery, or motors is too high the robot will not run. Allow it to cool off, after which it should operate normally.

All the LEDs flashing red indicates a more serious problem. Contact service@franklinrobotics.com in this case.

Tertill Assistance

Tertill is designed to live in your garden taking care of weeds and itself. However, Tertill may occasionally need a little help. We recommend that you check the status of your robot at least every few days. Look for the following:

Stuck

Has the robot tumbled over or become stuck in some way? If it has please move it to a safe area and press the power button to start it running again. If possible, it is also advisable to repair whatever condition caused Tertill to become stuck. E.g. Is there a hole or rut that should be filled or an awkward rock that could be removed?

Mud

Depending on weather and soil conditions, caked-on mud can sometimes impede Tertill. Mud sticking to the treads of the wheels usually dislodges once conditions change. However, mud can sometime accumulate beside and under the wheels to such a degree that the wheels cannot turn freely.

You can use water from a garden hose to clear mud from the wheels and any other surface to which it sticks. We recommend not using a spray head for this purpose. Also, do not immerse the robot in water and do not spray with a pressure washer. Tertill is sealed against rain but is not intended for full immersion or high pressure spray.

Debris

Stringy debris can sometimes become wrapped around the wheels or the whacker. Carefully remove such debris, preferably by unwinding it. Only in extreme cases, should you remove the problem wheel using the supplied wrench. Then clear the debris and replace the wheel. Do not over tighten the nut!

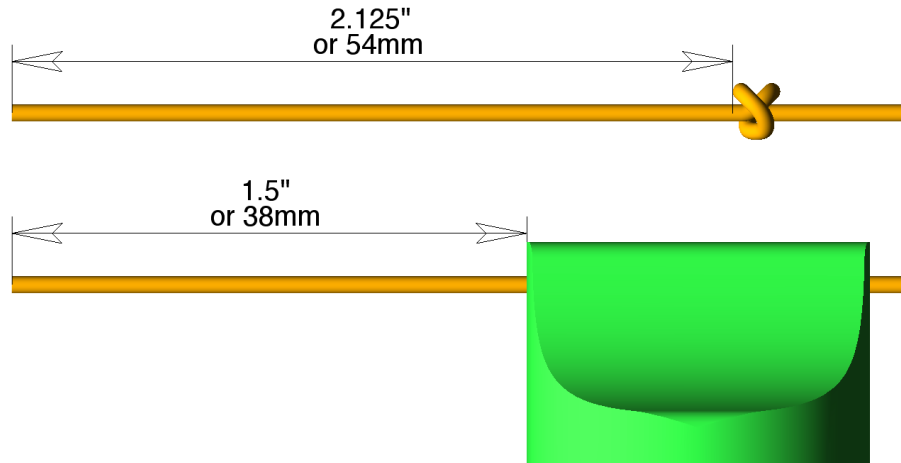
Solar cell

Clear away any dust or dirt that accumulates on the solar cell to keep it at peak efficiency.

Whacker wear

The whacker string will gradually wear and shorten. How long the whacker lasts depends on your local weeds, soil type, and prevalence of rocks. When the whacker is shorter than about an inch (2.5 cm) it should be replaced.

To replace the whacker string hold the hub with the fingers of one hand then, holding the string near the hub with the other hand, push the string into the hub. In difficult cases pliers might be needed to force the string into the hub. Discard the old string. Reverse the operation to install a new string.



Additional whacker strings are available from Franklin Robotics. You can also construct your own from residential grade 0.050" (1.27 mm) trimmer string. To do this, tie a knot in one end of the string, push the string into the hub, and then clip off the end such that about 1.5" (3.8 cm) of string is left protruding from the hub. You can leave a short bit of string (no more than 0.25" or 5 mm) extending from the opposite side of the hub. This will make it easier to remove the string next time. Do not use glue to hold the string in place.

Storage

If Tertill is to be out of service for a long period, say over the winter, place it in Hold mode as described above and keep it in a dark place. Stored in this way Tertill will not wake up and try to establish a Bluetooth connection. During storage a USB cable should not be connected.

Tertill App

Tertill's smart phone application lets you check Tertill's status remotely. The app also provides a way to update the software on your robot. You will find the latest iPhone version on the Apple app store, the Android version is available through Google Play.

The Tertill App is an accessory to Tertill and is not necessary for its operation. The robot will remove weeds just as effectively without the app.

Bluetooth

Bluetooth provides a wireless connection between Tertill and the app running on your smart phone. The app displays the status of any Tertill within range. Note however, that a Bluetooth connection is not available when the robot is charging in the sun or hibernating (see the Operating Modes section, page 21).

Frequently Asked Questions

Q: Should I bring Tertill indoors when it rains?

A: No. Tertill can handle the same weather conditions as garden plants.

Q: Should I bring Tertill indoors if the weather is too hot?

A: This is not necessary. Tertill has a built-in temperature sensors. If the weather is too hot for safe operation Tertill will wait until the air is cooler.

Q: Does Tertill charge its batteries while patrolling?

A: Yes, Tertill uses all available energy. However, driving and whacking require more power than the solar cell can supply continuously. So even on a sunny day Tertill will eventually have to stop and collect more energy.

Q: Does Tertill work on cloudy days?

A: Tertill uses as much energy as is available to remove weeds. Less energy is available on cloudy days and the robot operates less frequently then. However, weeds need energy too and cannot grow as rapidly during cloudy stretches.

Q: Will Tertill work on straw mulch/rubber mulch/sawdust... ?

A: Tertill is designed to work with commonly used garden ground-cover material.

Q: Tertill leaves tracks in my garden, is that a problem?

A: When the soil is soft and loose, as it may be immediately after tillage, Tertill will leave tracks. After a good rain or after the garden has been watered a few times tracks should be less visible.

Q: Will Tertill work on my patio or walkway?

A: Yes, assuming the surface is reasonably flat. But remember that Tertill needs a physical boundary to keep it from wandering away or falling over a cliff.

Q: Will Tertill mow my lawn?

A: No. Tertill's whacker is designed for small weeds and is not effective against mature lawn grass. Also, Tertill's solar cell cannot collect enough energy to cover a typical lawn.

Q: Tertill doesn't cut every visible weed. Is something wrong?

A: No. Tertill sometimes drives over a weed without sensing it. But the robot is relentless, it will return again and again. Eventually, it will either grind weeds into the ground with its wheels or chop them with its whacker.

Q: Won't chopping weeds as Tertill does just spread their seeds and cause more weeds in the future?

A: No. Weeds, like all plants, must reach a certain level of maturity before they "set seed." Tertill attacks weeds at the sprout stage before they've had a chance to produce and release seeds.

Q: How well does Tertill control weeds?

A: To get a idea of how well Tertill works for you, you can conduct a scientific test. Block off a strip of bare land in or adjacent to your garden—leave this soil fallow and out of Tertill's reach. By the end of the season you'll see what your garden would have looked like had Tertill not been working for you.

Q: Is it OK to have two Tertills in the garden at the same time?

A: Yes, multiple Tertills can work in the same space without interfering with each other.

Q: I'm really curious about what's inside Tertill, can I take it apart?

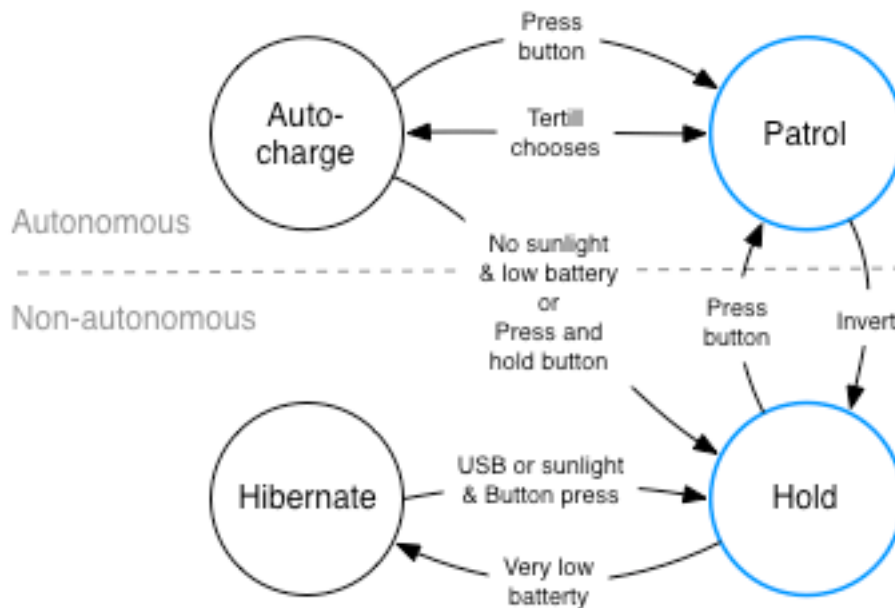
A: **NO!** Tertill is assembled at the factory in a way that makes it waterproof under normal circumstances. If you take it apart, then put it back together it's likely the waterproof seal will be compromised. If this happens Tertill could drown in the next rain storm.

Troubleshooting

Symptom	Cause	Remedy
LEDs don't turn on	Battery charge too low	Leave robot in sun or charge via USB port
Robot turns away from big weeds	Tall plants aren't recognized as weeds	Remove tall weeds manually
Small weeds aren't cut	Weeds too short to be sensed	Wait, weeds will be cut when they grow and trigger sensor
Robot doesn't cover the whole garden	Vegetation is too dense	Reposition leaves to give Tertill a clear path. Raise leaves so Tertill can run under leaves.
Robot doesn't start automatically	1) Extended cloudy period 2) Robot is in Hold mode	1) Wait for sun or charge via USB 2) Press power button to enter patrol mode
Robot gets stuck	Garden contains a terrain trap	Eliminate ruts, holes, or rocks that can trap Tertill
Robot patrols but weeds are growing	1) Whacker string too short 2) Garden is large	1) Replace string 2) Use supplemental USB charging so robot runs longer

Advanced Tertill

Tertill seems simple enough—it moves about the garden and chops down weeds. But there's lots going on under the hood and there's additional complexity in the way Tertill interacts with the environment. This section is for those who are curious about such things.



Operating modes

The diagram shows a simplified version of Tertill's operating modes and the events that trigger a switch from one mode to another. Blue-outlined modes show when a Bluetooth connection can be made.

Tertill is always in one of four modes: Auto-charge, Patrol, Hold, or Hibernate. Auto-charge and Patrol are autonomous modes. Tertill decides for itself when to switch from one to the other. As the names imply, Tertill charges its battery in Auto-charge mode and drives around searching for weeds in Patrol mode.

When you press and hold the power button or invert Tertill it goes into Hold mode. Tertill will not leave Hold mode and begin patrolling until you press the power button. Don't forget to press the button—Tertill will wait indefinitely for this authorization to enter Patrol mode.

Battery charge falls slowly over time (days) when no sunlight is available. At some point, to protect its battery, Tertill enters Hibernate mode. It can remain in this mode for months without damage. When you want Tertill to resume its duties, place it in bright

sunlight for an hour or so (or charge the battery using USB) then press the power button to bring Tertill back to Hold mode.

Programming paradigm

Tertill follows a robot-programming paradigm known as *behavior-based programming*. Specialized software modules (behaviors) control Tertill in specific situations. Sensor readings and time cause Tertill to switch from one behavior to another. This architecture makes Tertill highly responsive to conditions it encounters in the world.

Sensing

Tertill senses the world in several ways. It uses capacitive sensors to detect plants, weeds, and conductive obstacles. It has wheel rotation sensors to detect and control the motion of its wheels. It uses accelerometers and gyros to, among other things, detect non-conductive obstacles and avoid dangerous slopes.

The garden environment is a much more challenging realm than the floor of a living room (where robot vacuum cleaners have operated for years). The garden surface isn't flat, vegetation can build an inadvertent trap, the robot can accidentally dig a hole for itself, rocks can create a high-centering hazard, and sometime it rains.

Tertill does very well amid this verdant chaos but it occasionally encounters a terrain feature that confounds it. So you may occasionally find Tertill stuck. The best solution is to eliminate or alter the feature that caused the trouble. If there's a rut or a depression, fill it. Remove troublesome rocks and block off entwining vegetation with a plant or row collar.

From Tertill's point of view, rain looks a lot like plants. When the sprinkler is going or rain is falling, a coat of water on Tertill's chassis may make the robot think it's surrounded by plants. If this happens it will spin in place a couple of times, looking for an escape path, and then stop (enter Auto-charge mode). After a while it will try again. As soon as it's mostly dried off Tertill will patrol as usual.

Sometimes Tertill may find its way into a position where it really is completely surrounded by plants. In this case you will have to intervene. Place the robot in a different spot where it has room to maneuver.

Scrubbing weeds

When weeds sprout from seeds they pass through the "cotyledon" or white thread stage. In this part of their life cycle they are quite vulnerable to disturbances in the soil. That's one reason that Tertill has treads (or grouzers) on its wheels. As it drives about, the grouzers scrub the soil and can kill the emerging weeds.

Some soil types, however, are more protective of early stage weeds than others. In sandy, loose soil Tertill is more effective at killing small weeds than in compacted or clay-rich soils. If you have the latter type of soil you can help Tertill by occasionally raking or otherwise loosening the soil surface.

Big Gardens

Tertill was designed with the typical size garden in mind. The median area of a US garden is about 100 square feet (9.3 square meters). If your garden is significantly larger than this and weeds seem to be gaining on Tertill, you may want to take some additional steps.

Make sure that Tertill operates as efficiently as possible. Take extra precautions to remove rocks and smooth the surface. Use a fence that Tertill can detect (e.g. wood or wire). Increase the spacing between crop rows and individual plants (for next season).

Give Tertill extra weeding time by occasionally charging its battery via USB. After charging in this way Tertill may run for about an hour. You can even use this method to enable Tertill to chop weeds at night. Supplemental charging enables Tertill to work much longer than when it relies on solar power alone.

If weeds tend to be more of a problem in one part of the garden than another you can put up a temporary fence. Confine Tertill to the problem area until it has eliminated the weeds there.

If all else fails, consider getting your Tertill a buddy—two Tertills do twice the work of one. Multiple Tertills can work together in the garden without interfering with each other.

Cautions

- Do not disassemble Tertill. There are no user serviceable parts inside. If service is required contact Franklin Robotics.
- Do not immerse Tertill in water and do not spray with a high pressure sprayer.
- Do not operate Tertill in the garden with the waterproof USB port cap removed.
- Do not expose Tertill to fire or flame.
- Do not operate Tertill in an explosive environment.
- Do not place anything on top of Tertill as it operates.
- Do not use trimmer string other than the string supplied or residential grade 0.050" string.
- Pick up Tertill only from the back using the molded-in handle. Picking Tertill up from the front may activate the weed whacker.
- Keep your eyes a safe distance from Tertill's whacker string. The whacker can potentially fling small debris.
- Tertill is not a toy. Do not allow children to play with Tertill or to play unsupervised in a garden where Tertill is working.

Regulatory Notes

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) This device must accept any interference received, including interference that may cause undesired operation.

Franklin Robotics, Inc. is not responsible for any changes or modifications not expressly approved by Franklin Robotics, Inc. Such modifications could void the user's authority to operate the equipment.

FCC Statement

FCC ID: 2APTN-TERTILL001

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experience radio/TV technician for help.

Canada Statement

IC: 23895-TERTILL001

This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

- (1) This device may not cause interference; and
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

- (1) l'appareil ne doit pas produire de brouillage;
- (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Contact Information

Franklin Robotics, Inc.

85 Rangeway Rd

Building 1 – 1st Floor

North Billerica, MA 01862

support@franklinrobotics.com