FIRST® LEGO® League Challenge SUBMERGED℠ Building Instructions

Build 10: Sonar Discovery

This build is 107 pieces, and 31 building steps.

Welcome to text-based instructions from Bricks for the Blind. Before you start building, here are some terms we'll be using:
- In Front of/Front: towards you.
- Behind/Back: away from you.
- Up: towards the ceiling.
- Down: towards the floor.
- Stud: the bump on a LEGO brick. Example: A 2x1 brick has two studs on it.
- Vertically: going from front to behind.
- Horizontally: going from left to right.
- Upright: pointing up towards the ceiling.
- That one/ppp: previously placed piece.
- Plate: piece with studs.
- Tile: smooth piece without studs (unless otherwise specified)
- Symmetrically: a mirror image. Example: If you place a 2x1 brick with technic connector on the front wall at the right, connector to the front, and then place another such piece symmetrically on the back wall, at the right, the technic connector of the second piece should point to the back, since it will be placed symmetrically.
- Centered-vertically: even amount of space in front of and behind the piece
- Centered-horizontally: even amount of space left and right of the piece.
- Row: studs lined up horizontally (left to right/side to side).
- Column: studs lined up upright or vertically (top to bottom/back to front).
- Standing upright: the piece is perpendicular to the ground, like a wall.
- Lying flat: the piece is parallel to the ground, like a piece of toast which fell off the table.
- Anti-stud: the portion of a piece which accepts studs, like the bottom of a plate.
- Jumper plate: a 1x2 plate with a single stud on top, or a 1x3 plate with only two studs on top.

A note on LEGO Technic™ part names. These parts are somewhat different from regular LEGO bricks. Here are some definitions in case the builder or helper is not familiar with LEGO Technic™.

Axles - An axle is a connector which has an X shaped cross-section. Because their cross section is not round, anything connected to an axle using an axle-hole will rotate with that axle. Axles are longer than they are wide, and the length of an axle corresponds with how many bricks long it is. Aka a 3L axle is three bricks long. Axles come in a variety of lengths, with a 2L axle being the shortest available. They may be combined with pins, or have circular stops on them. A stop prevents the axle from sliding through an axle-hole at a specific point on the axle.

Pins - A pin is a connector which has a circular cross section and a flanged notch out of one or both ends. This flanged notch allows them to click into bricks with a pin-hole. Pins come with and without friction ridges, which are small bumps on the pin which prevent them from rotating freely. For standard pins, black is a high friction pin, and gray is a low friction pin. A standard length pin is two brick lengths long, with a stop in the middle. This prevents a brick from being pushed from one side of the pin to the other. A 1L pin is one brick long and still retains the stop, however it also includes a hollow stud at the other end. A 3L pin is three bricks long, and only contains a stop at one side, allowing two bricks to be pushed onto the other side of the pin. Pins may also have one side which is an axle.

Lift-arms - A lift-arm is a basic structural element, similar to a brick or a plate, but usually without any studs. It is a beam with rounded ends and with holes in it, with the same spacing as the studs on a LEGO brick. lift-arms come in a variety of lengths, including a 1x1 lift-arm which looks like a cylinder. Thick lift-arms are as wide as a LEGO brick, and thin lift-arms are half as wide as a LEGO brick, but not the same thickness as a LEGO plate! The holes in a lift-arm arm may accept axles or pins. They also come in a variety of shapes, including tees, ells and triangles.

Gears - A gear is a functional element. They are typically discs with teeth on the outside, there are also worm gears which look like a spiraling cylinder! Gears connected by axles transmit or even transform rotational motion!

Axle and Pin Connectors - These elements are typically smaller than lift-arms and are used to connect some combination of pins or axles. They might have pins or axles, as well as axle or pin-holes. They have a lot of different angle combinations! The simplest just connects two axles or pins together in a straight line.

Bushes/Bushings - LEGO Technic™ uses bushes largely as spacers, but they also can reduce friction between rotating parts, or can form useful elements such as handles. Bushes are typically light gray, generally cylindrical, and have an axle-hole running through the middle. They have a flange at the front and back to make them easier to pull on and off.

Technic™ Bricks and Plates – There are also regular bricks and plates that are adapted for use with Technic™ elements. Technic™ bricks have holes for either pins or axles on the sides and are only one brick wide. One of the most common of these is a 1x2 brick with a single pin hole. Most often, these bricks have pin holes, not axle holes. Technic™ plates have holes on the flat surface between the studs and are a minimum of two bricks wide. The holes in these plates can accept pins or can allow an axle to pass through and still spin.

For builders with low vision, or a sighted building partner who may want to follow along with the printed visual instructions that come with each set. As low vision users may benefit from viewing the instructions on a personal device where they can zoom in on content and use assistive technologies to enhance the visuals.

Sorting the pieces:

This LEGO set comes in the bags labeled 21-22. Additional pieces are in the unlabeled bag. Sort the pieces into groups as described below. Note that where there are multiple colors of the same brick in a step, the colors will be split across two groups to make telling the difference easier for the builder! LEGO includes a few spare parts in case you lose something. Set these into their own group away from the rest, in case you need them later.

Build 10 (8 groups of bricks)
Group A contains all of the black 2L pins from this bag. These pins have friction ridges.
Group B contains all of the blue 3L pins from this bag. These pins have friction ridges.
Group C contains all of the blue 2L axle/pin combos from this bag. These pins have friction ridges.

Group 1 contains the pieces for steps 1-6.
Group 2 contains the pieces for steps 7-12.
Group 3 contains the pieces for steps 13-20.
Group 4 contains the pieces for steps 21-28. This includes four black 11x11 curved gear racks and one yellow 13L liftarm from the unlabeled bag.
Group 5 contains the pieces for steps 29-31.

Building Instructions:

Main build.

Open groups A, B, C and 1. You will use the pins from groups A, B and C throughout the build.

1.1. Let's start by building the central support of the sonar screen. Place a lime green 11L liftarm in front of you, horizontally with the holes facing forward.

1.2. Find a black 3L axle/pin combo which has a 1L pin and a 2L axle side. Push this piece, with the axle side at the front, from the front into the rightmost hole of the previous piece. The axle will extend 2L to the front.

2. Push two black 2L pins from group A, from the back into the second and fifth holes from the left side of the 11L liftarm. There should be two holes between these two pieces.

3. Push a lime green 11L liftarm, horizontally with the holes facing forward, from the back onto the pins from the previous step. The right hole of the liftarm goes on the right pin, so this liftarm extends 6 holes to the left of the first one.

4. Push two black 2L pins from group A**,** from the front into the leftmost and fourth from the left holes on the previous piece. There should be two holes between these two pieces.

5.1. Push a lime green 11L liftarm, from the front, onto the pins from the previous step. The second from the right hole on the liftarm goes on the right pin, so the rightmost hole of the 11L liftarm will be free and its left side should extend 6 holes to the left of the liftarm behind it.

5.2. Find a black 3L axle/pin combo which has a 1L pin and a 2L axle side. Push this piece, with the axle side at the front, from the front into the third hole from the left of the previous piece. The axle will extend 2L to the front.

6.1. Find the two axles extending to the front of the assembly. Find a dark gray 3L axle and pin connector with a perpendicular pin hole. This looks like a 3L liftarm, except that the holes on the end are axle holes that are perpendicular to the center pin hole. Push the right axle hole of one of these pieces, horizontally with the axle holes facing forward, from the front onto the previous piece so the left side of the piece is even with the left side of the build.

6.2. Repeat the previous step symmetrically on the right side, except that you will have to use the right hole of the piece to make its right side even with the right side of the build.

6.3. Find a black 3L axle/pin combo which has a 1L pin and a 2L axle side. Push this piece, with the axle side at the back, from the front into the left hole of the previous piece. Push it all the way in so only the pin extends to the front.

6.4. Repeat the previous step on the left side of the build, except that you will have to push it into the left hole of the 3L axle and pin connector.

Open group 2.

7.1. Now we'll make the turntable for the sonar sweep! Find a black 28 tooth turntable. This piece looks like a gear with 28 teeth, with two pin holes on one side. The center of this piece is hollow. Place it in front of you, with the pin holes at the bottom facing forward.

7.2. Push two blue 3L pins from group B, with the stop rings at the front, from the front into the pin holes of the previous piece. Push them all the way back so they extend 1L to the front and back.

7.3. Find a light gray small turntable top. This is a thin cylinder with two pin holes on one side. Push this piece, with the pin holes on top, into the hollow on top of the turntable. Push it down until it clicks. When it clicks, it should spin easily. The orientation of the pin holes does not matter right now.

7.4. Push the two rear facing pins on the turntable assembly, from the front, into the two holes on either side of the middle hole on the main assembly.

8. Push a lime green 11L liftarm, horizontally with the holes facing forward, from the front onto the three pins on the left side of the assembly. Its left side should be even with the left side of the assembly. Repeat this symmetrically on the right side.

9.1. Find a light gray axle and pin connector #2. This piece has two 1L axle connectors on opposite sides, and a perpendicular pin hole between them. Push this piece in front of you, with the axle connectors at the front and back and the pin hole facing up.

9.2. Push a light gray 9L axle, vertically from the front into the front axle connector. Push another symmetrically from the back side.

9.3. Keeping the pin hole on the axle connector facing up, push the back axle through the middle hole of the main assembly. Push it all the way back. The pin hole should be in line with the hole in the center of the turntable.

10.1. Find a lime green 3L pin with a bushing on one side. This looks like a 2L pin with no stop rings and a thick cylinder on one side. This cylinder looks identical to a bushing and has an axle hole through the center. Place this piece in front of you, with the bushing side at the right.

10.2. Push a tan 2L axle pin combo, with the axle on the left, from the right into the bushing portion of the previous piece.

10.3. Rotate these two pins 90 degrees clockwise so the previous piece is at the bottom. Push this from the top, through the holes in the turntable and connect it to the axle and pin connector connected to the two axles.

11. Push two black 2L pins from group A, from the front into the second and fifth holes to the left of the axle on the front side of the assembly. Repeat this symmetrically on the right side.

12. Push a lime green 11L liftarm, horizontally with the holes facing forward, from the front onto the four pins from the previous step. The axle will pass through the middle hole of this piece.

Open group 3.

13.1. Next, we'll make two identical L-shaped assemblies. Set the rest of the sonar screen aside for now. Place a lime green 3x5 L-shaped liftarm in front of you, with the long leg upright on the left and the short leg at the bottom pointing horizontally to the right.

13.2. Push a black 2L pin from group A, from the front into the rightmost hole of the previous piece.

13.3. Push a blue 3L pin from group B, with the stop ring at the back, from the front into the hole to the left of the previous piece. Push it all the way back so it extends 2L to the front.

14. Push a lime green 3x5 L-shaped liftarm, in the same orientation as the first one, from the front onto the two pins. It should be even with the first L-shaped liftarm. Push it all the way back so the 3L pin extends 1L to the front.

15. Push a blue 3L pin from group B, with the stop ring at the back, from the front into the middle hole on the upright column of the previous piece. There should be two free holes above and below this pin. Push it all the way back so it extends 2L to the front.

16. Push a lime green 3x5 L-shaped liftarm, with the short leg upright on the left and the long leg at the bottom pointing horizontally to the right, from the front onto the two exposed pins. It will extend two holes to the right of the other two liftarms. Push it all the way back so the left pin extends 1L to the front.

17.1. Now we'll extend the bottom leg of the L-shaped assembly. Place a green 5L liftarm in front of you, horizontally with the holes facing forward.

17.2. Push a blue 3L pin from group B, with the stop ring at the front, from the front into the leftmost hole of the previous piece. Push it all the way back so it extends 1L to the front and back of the previous piece.

17.3. Push a blue 3L pin from group B, with the stop ring at the back, from the front into the hole to the right of the previous piece. Push it all the way back so it extends 2L to the front.

17.4. Push a black 2L pin from group A, from the back into the rightmost hole of the 5L liftarm.

17.5. Push a green 5L liftarm, horizontally with the holes facing forward, from the back onto the two exposed pins. Its left and right sides should be even with the first liftarm.

17.6. Find the front L-shaped liftarm on the L-shaped assembly. It should extend two holes to the right of the other two L-shaped liftarms. Push the two pins on the extension, from the back, into these two holes. Push the extension all the way forward so one pin extends 1L past the rest of the assembly.

18. Push a lime green 3x5 L-shaped liftarm, with the short leg upright on the left and the long leg at the bottom pointing horizontally to the right, from the front onto the two exposed pins. There should be no exposed pins on this assembly.

19.1. Place the rest of the sonar screen in front of you, with the liftarms running horizontally and the axle vertically. The turntable should be at the top. Take the L-shaped assembly you just made, with the extension lying flat and pointing to the right and the other leg pointing up and slide the corner hole over the front axle. Slide it all the way back until it touches the rest of the sonar screen.

19.2. Repeat steps 13-18 to create another L-shaped assembly. Place this assembly on the back side, with the extension lying flat and pointing to the left.

20.1. Find a lime green 2L pin connector. This piece looks like a smooth cylinder which is 2L long and has a small notch in the middle. Slide this piece, from the front onto the front axle until it touches the L-shaped assembly. This piece will not attach to the axle, instead it will spin freely.

20.2. Find a lime green axle and pin connector #1. This piece has a 1L axle connector on one side, and a perpendicular pin hole on the other. Push this piece, with the pin hole at the front with the hole facing up, from the front onto the front axle.

20.3. Repeat steps 20.1-20.2 symmetrically on the back side.

Open group 4.

21.1. Next we will build the circular border that goes around the sonar screen. Find the two top-facing holes on the previous two pieces. Push two blue 2L axle/pin combos from group C, with the pins at the bottom, from the top into these two holes.

21.2. Find the two top facing holes on the left and right sides of the screen. These are between the two long liftarms. Push two blue 2L axle/pin combos from group C, with the pins at the bottom, from the top into these two holes. There are now four pins, one each at the front, left, right, and back.

21.3. Find a black 11x11 curved gear rack. This looks like a quarter of a circle, which is smooth on the outside and has teeth like a gear on the inside. It has four pairs of pin holes around the edge, and an axle hole at each end. The axle holes are offset to one side, so if you lay it flat one way, they are on top, and if you lay it the other way they are on the bottom. Push this piece, with the axle holes at the bottom and the smooth side at the front left, down onto the front and left axles from the previous two steps. Repeat this on the back and right axles, with the smooth side at the back right.

22. Push a black 11x11 curved gear rack, with the axles holes at the top and the smooth side at the back left, onto the left and back axles. Repeat this on the front and right axles, with the smooth side at the front right. This should create a circle around the sonar screen, which is smooth on the outside and has teeth on the inside.

23.1. Now we will make the sonar sweep. This is the line that sweeps back and forth on the sonar screen. Set the rest of the sonar screen aside for now. Note that the two L-shaped assemblies are not rigidly attached and will spin when you pick the assembly up. This is OK. Place a yellow 13L liftarm in front of you, horizontally with the holes facing up.

23.2. Push two black 2L pins from group A, from the top into the leftmost and third from the left holes on the previous piece. Repeat this symmetrically on the right side.

24. Push a yellow 3L liftarm, horizontally with the holes facing up, from the top onto the right pair of pins from the previous step.

25.1. Place a dark gray 3L axle and pin connector with a perpendicular pin hole in front of you, vertically with the axle holes facing left and right.

25.2. Find a black 3L axle/pin combo which has a 1L pin and a 2L axle side. Push this piece, with the axle side at the right, from the left into the front hole of the previous piece. The axle will extend 1L to the right and the pin will extend 1L to the left.

25.2. Push another black 3L axle/pin combo, with the axle side at the left, from the right into the rear hole of the 3L axle and pin connector. The axle will extend 1L to the left and the pin will extend 1L to the right.

25.3. Find a dark gray 2x3 U-shaped liftarm. This looks like two parallel 2L liftarms connected by a 1L liftarm whose pin hole is perpendicular to the holes on the 2L liftarms. Push two corner holes this piece, vertically with the two 2L liftarms pointing down, from the right onto the pin and axle on the right side. Repeat this symmetrically on the left side. When complete, this assembly should look kind of like a table with the 2L liftarms pointing down on the four corners. The holes on the 2L liftarms should be facing left and right.

25.4. Keeping it in the same orientation, push the left and right top facing holes on the table assembly, from the top onto the two pins on the left side of the sonar sweep.

26. Now place the sonar screen in front of you, with the axles vertical and the turntable on top. Rotate the two L-shaped assemblies so the longest sides lay flat. The back one should point to the left and the front one should point to the right. Rotate the turntable so the holes on the legs face left and right and the holes on the top face up. Keeping the sonar sweep horizontal, with the table at the left, push the pin on top of the turntable into the second top-facing hole from the left on the sweep.

27. Find a light gray 3L pin with an end stop. This looks like a normal pin, but one end has a wide end, kind of like a nail. This is the stop ring. Push this pin, with the stop ring at the left, from the left into the left-facing hole on the front left 2L liftarm on the table of the sweep. Push this all the way to the right so it goes through both front legs of the table and connects them to the turntable. Repeat this with the back pair of legs.

28. Now rotate the sweep clockwise until it touches the front L-shaped assembly. Find the right axle we used to connect the circular part of the sonar screen. This is where the sweep was located before we moved it. Now, trace the circle clockwise counting pin holes, which are in pairs. Push a red 1L pin with a ball on one side, with the ball on top, from the top into the fourth pin hole you find, which is the second pin hole in the second pair. Repeat this symmetrically going counterclockwise from the right axle. These are the stops for the sonar sweep.

Open group 5.

29.1. Now we will build the mounting legs for the sonar screen. There are four of them. Set the sonar screen aside for now. Find a light gray 11L liftarm with perpendicular holes. This looks like a normal 11L liftarm, except that every hole is perpendicular to its neighbors. Place this piece in front of you, horizontally with the smooth side at the front. The left and rightmost holes should be facing up.

29.2. Push two blue 3L pins from group B, with the stop rings at the bottom, from the top into the left and right holes of the previous piece. Push these all the way down so they extend 2L above the liftarm.

29.3. Push two black 2L pins from group A, from the front into the second holes from the left and right sides on the front of the 11L liftarm. There should be one hole between these two pieces.

30.1. Push a dark gray 7L liftarm, horizontally and centered horizontally, with the holes facing forward, onto the two pins from the previous step.

30.2. Find two light gray 1L liftarms. These look like hollow cylinders. Push these, with the holes facing up, from the top onto the two 3L pins. Push them all the way down so the pins extend 1L above them.

30.3. Repeat steps 29.1-30.2 three more times to make the other mounting legs.

31. Place the sonar screen in front of you, with the axle running vertically, the sweep on top, and the two stops for the sweep at the right. Rotate one mounting leg so the two free pins point up, and so the 7L liftarm is horizontally at the front. Push the two pins, from the bottom into the third holes on either side of the front axle used to mount the circular screen. Repeat this for all three of the mounting legs. Rotate the sweep all the way counterclockwise until it hits the front stop. Rotate the two L-shaped assemblies on the screen so their shortest side is pointing up.

Congratulations! Now this build is complete!

Thank you so much for building this set!

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