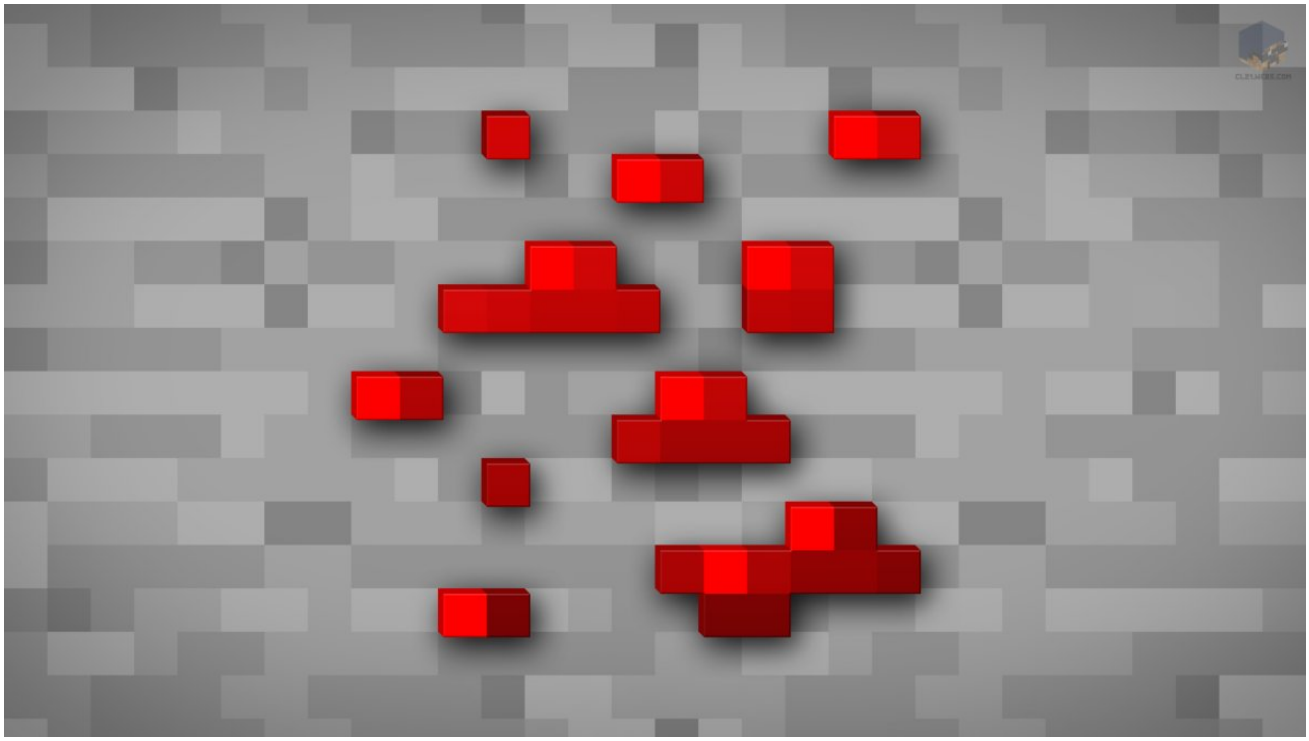


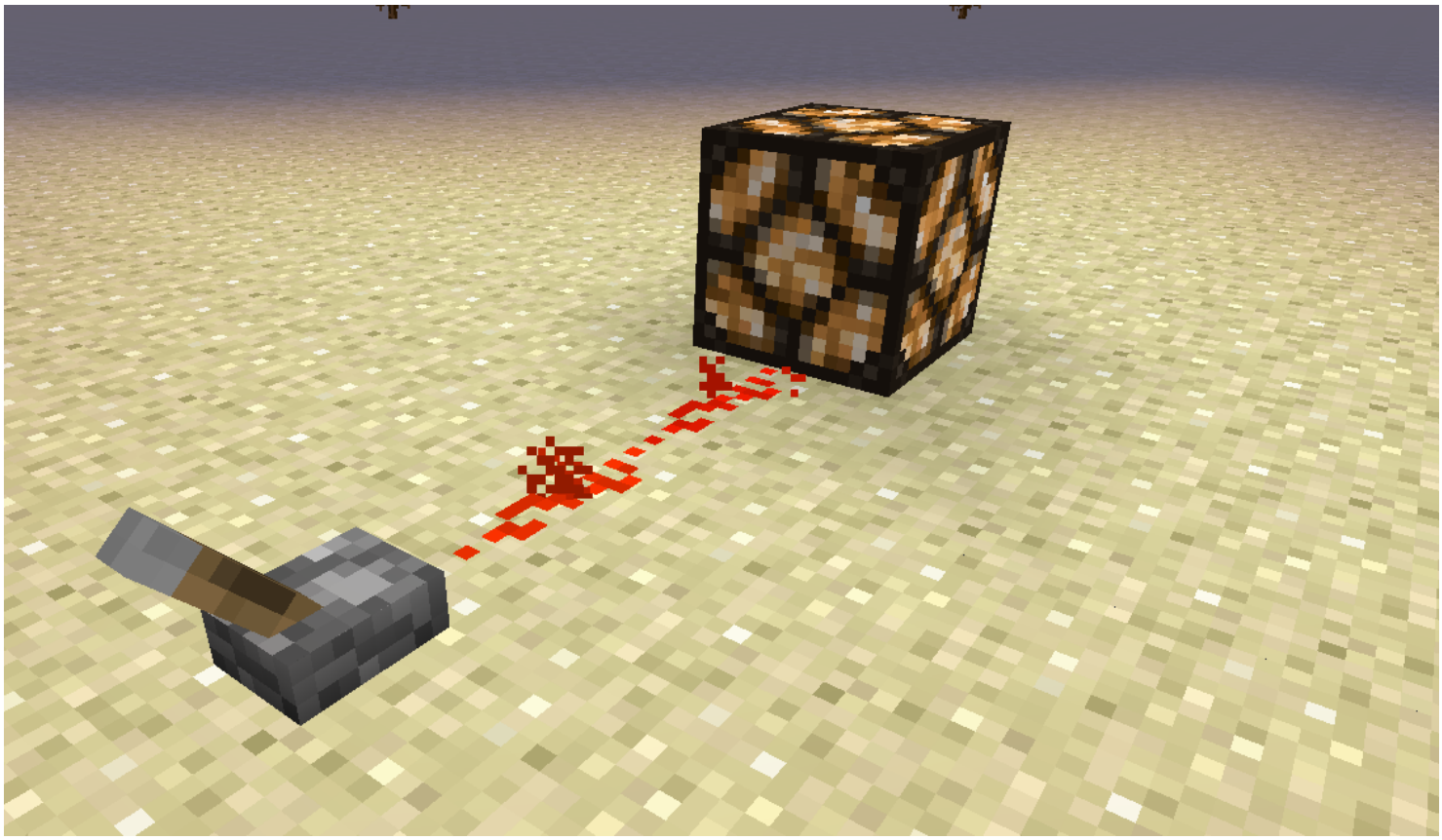
Minecraft U Sequence 2: I Sing the Minecraft Electric

Learn the basics of electricity, with in game and real world applications. We'll go over digital circuits, like those found in smartphones and tablets, and how to use them in the Minecraft world to build yourself awesome contraptions. At the advanced level, we'll go over what binary really is, and how to design binary logic machines with Redstone!

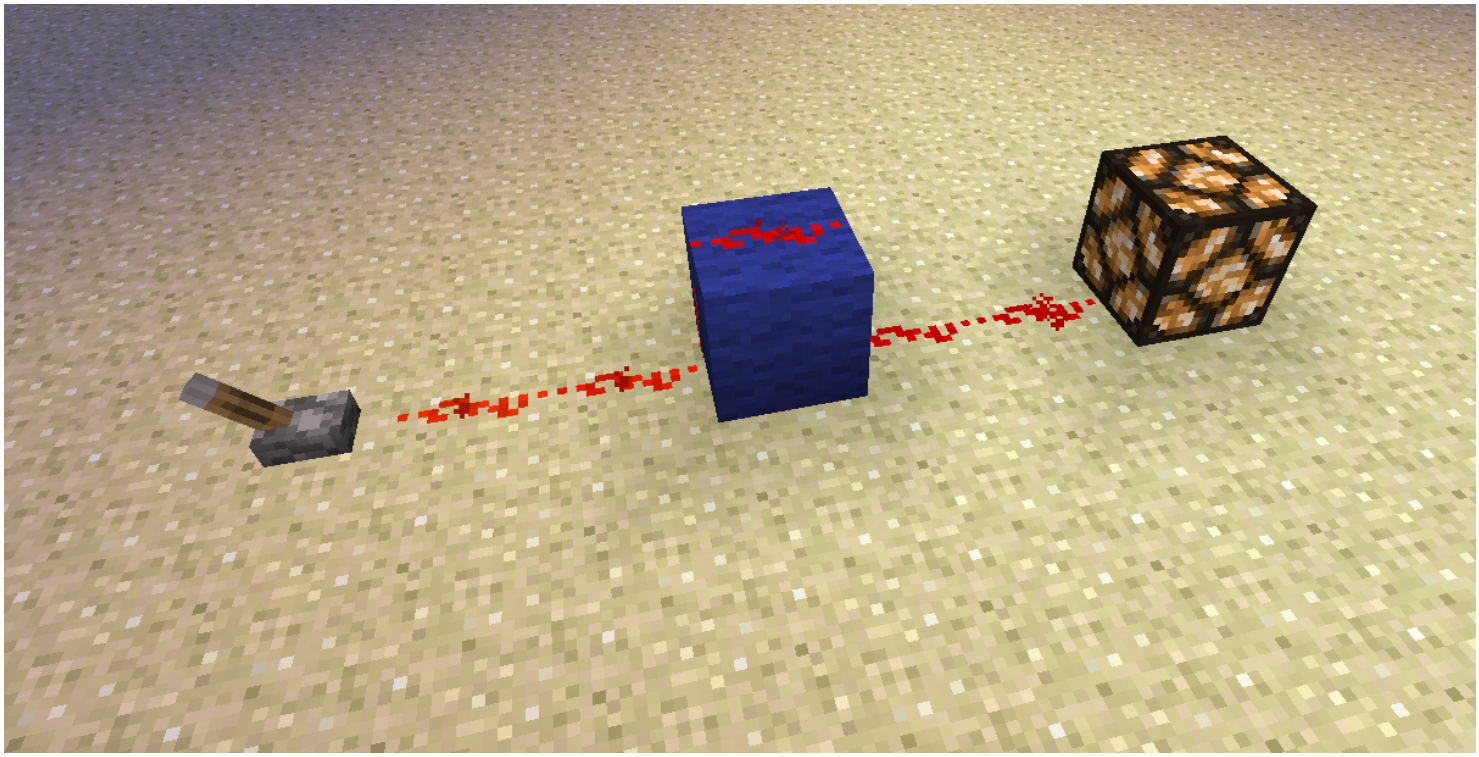
Table of Contents

Section 1: Redstone Basics

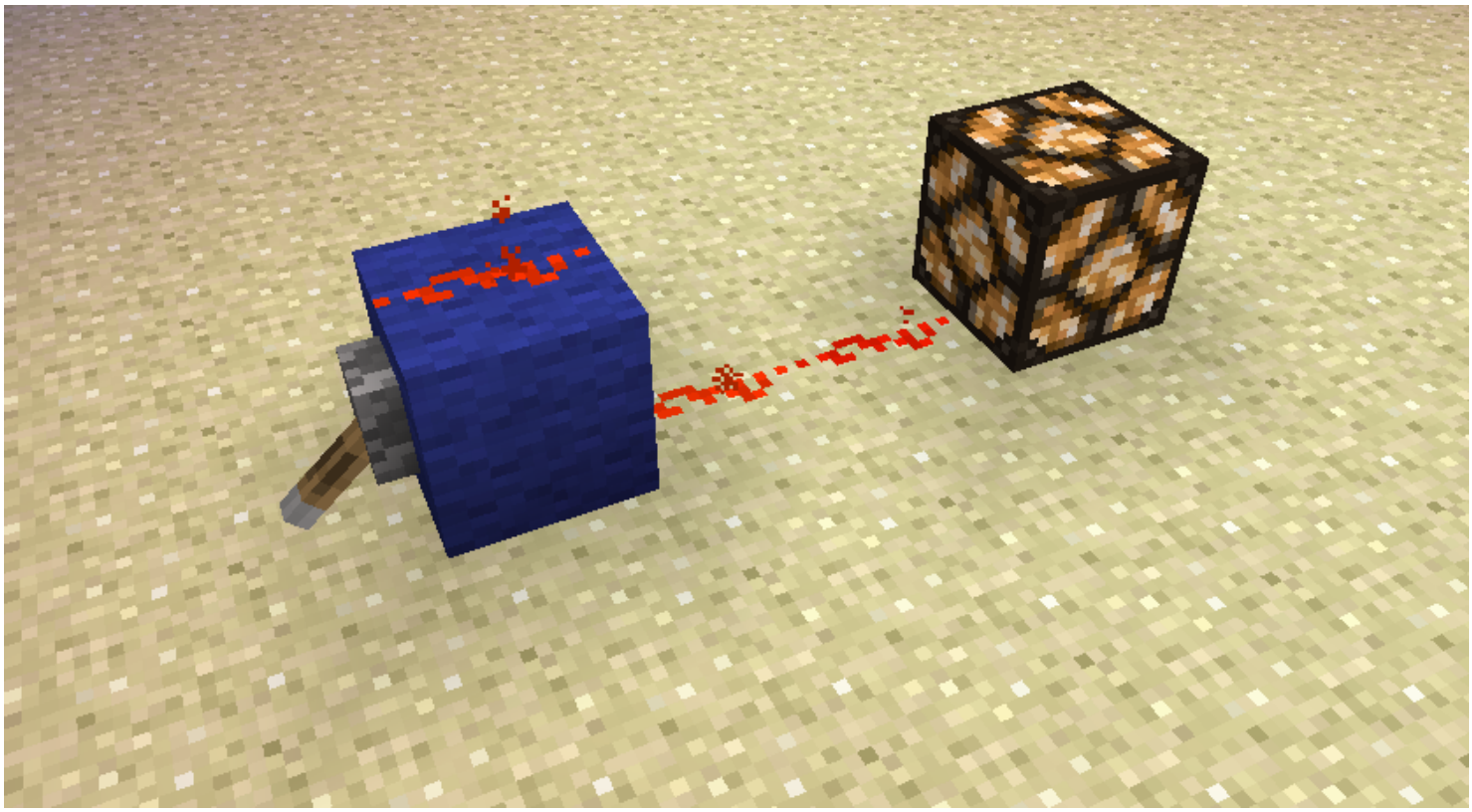
Redstone in Minecraft is a bit like electricity in real life. A redstone source transmits power through redstone dust (or repeaters) and can be used to power other blocks. For example, a lever in the ON position can be used to power a redstone lamp if at least two redstone dusts are placed between the two. THe two



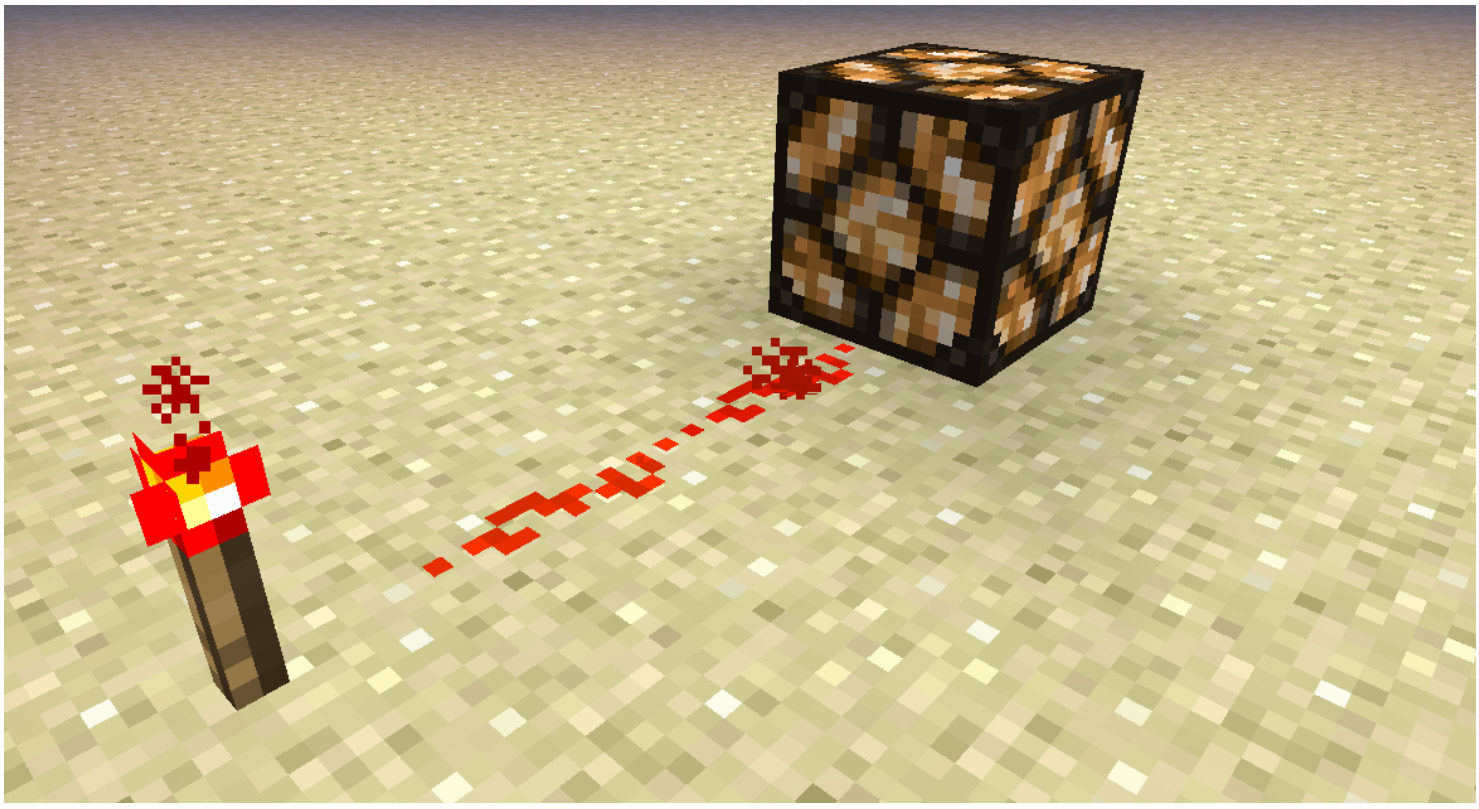
Redstone dust (also called redstone wire) can also bridge over individual blocks and still transmit power (also called redstone current).



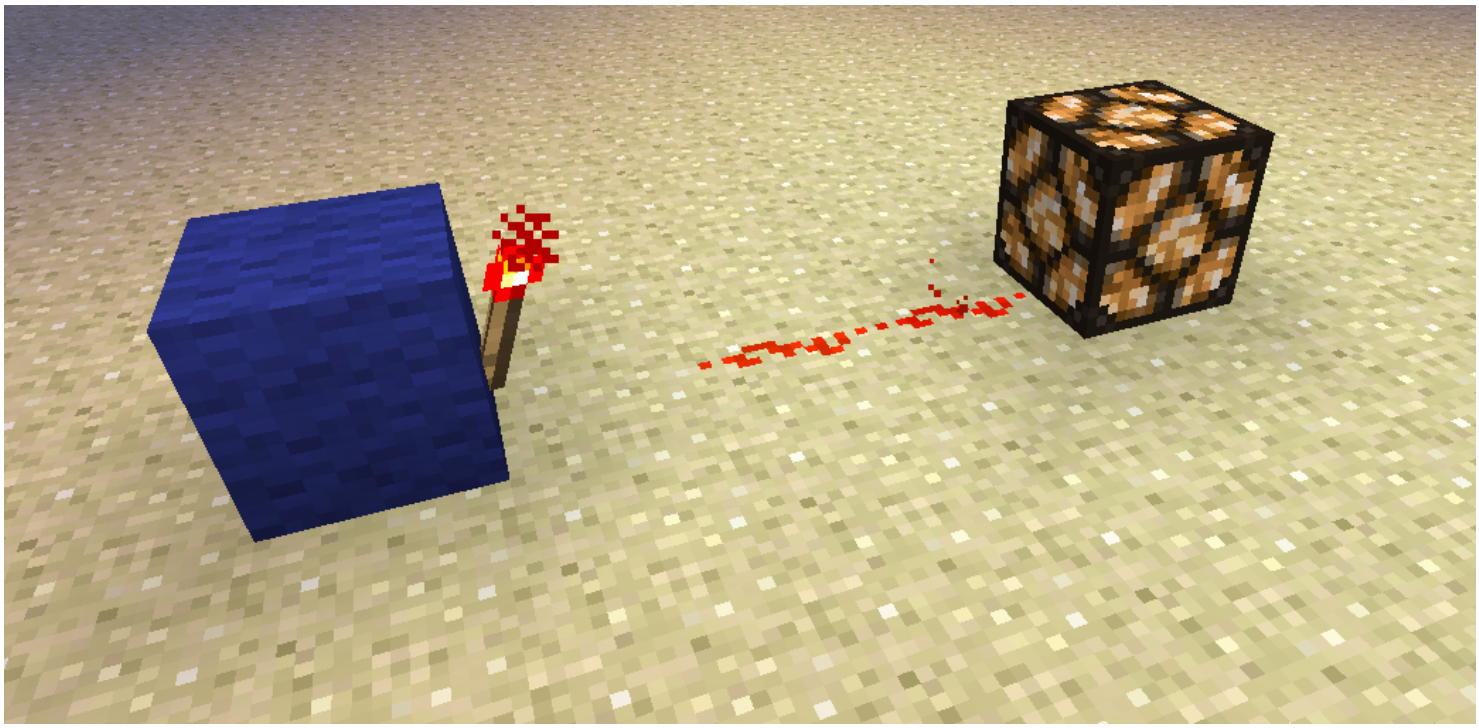
A lever placed directly onto a block powers the block itself, and redstone wire can carry current from the block to a lamp.



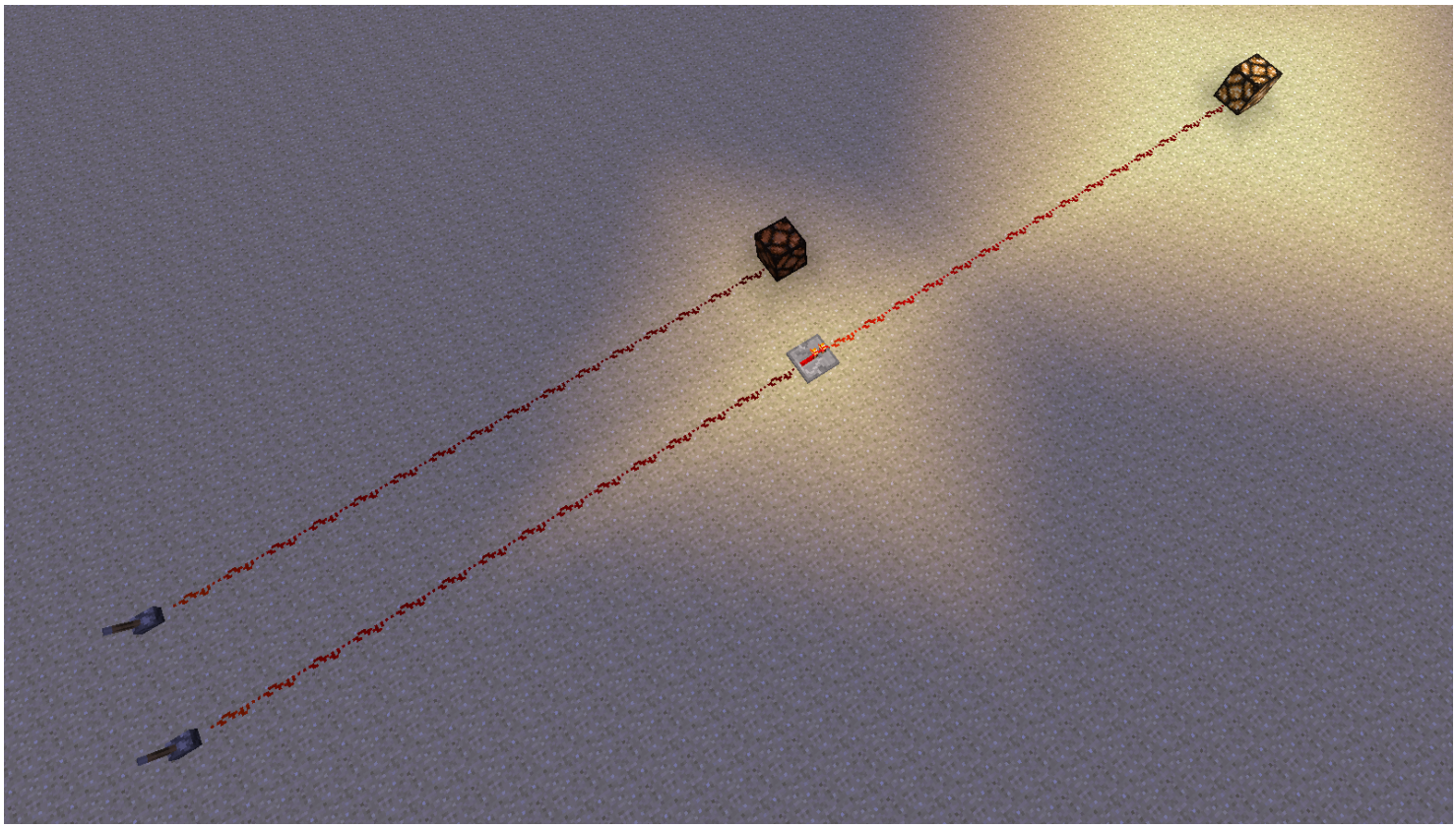
Redstone torches are a permanent source of redstone power; they are always ON and will always power adjacent redstone wire.



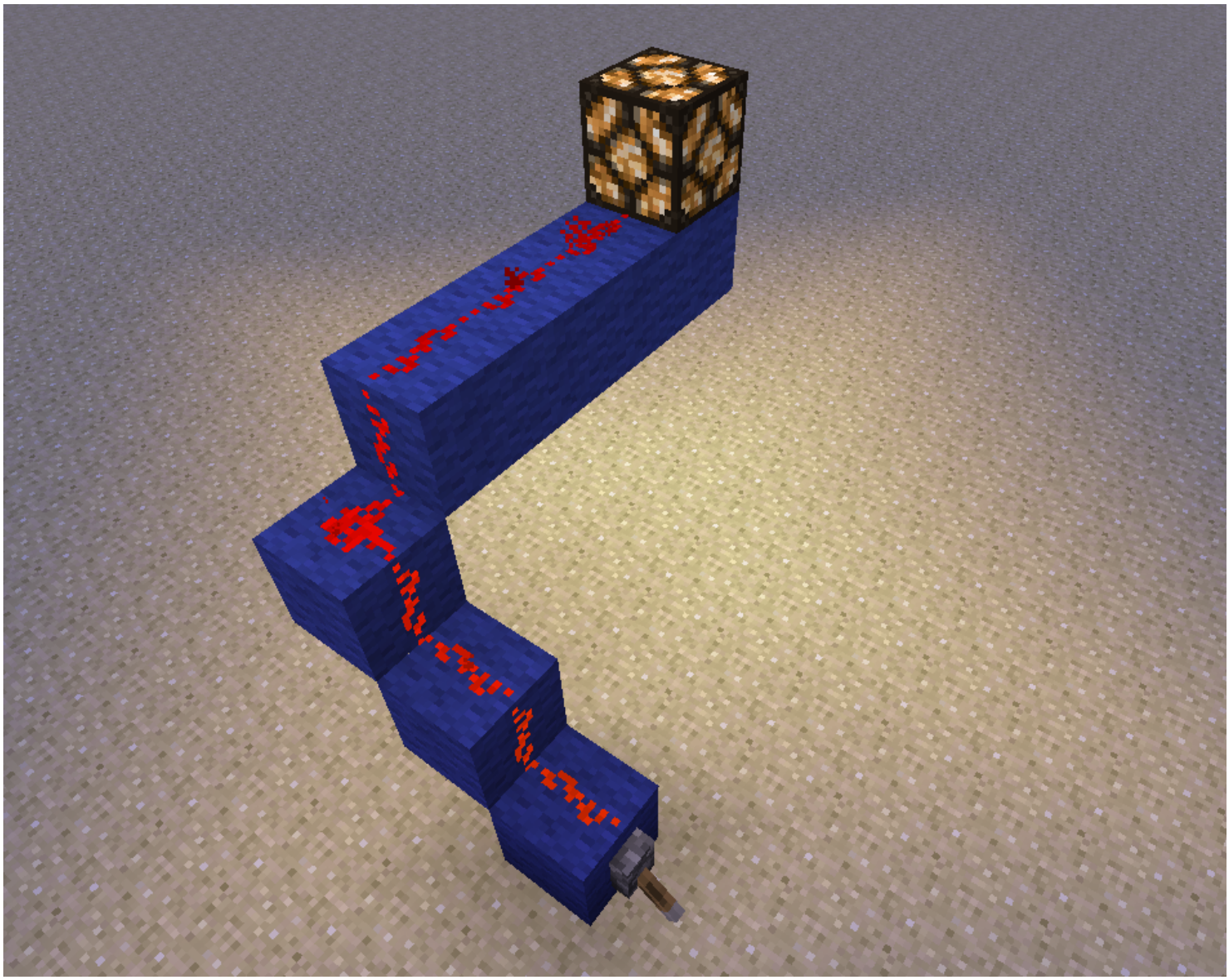
A redstone torch can be placed on the side of a block, too. Any adjacent redstone dust will also be powered.



Redstone current dies out after 15 blocks of redstone dust. Placing a repeater (which *repeats* the signal) will let a power source reach blocks even further away.



To move current upward, you must make stairs and connect the redstone dust going upward.



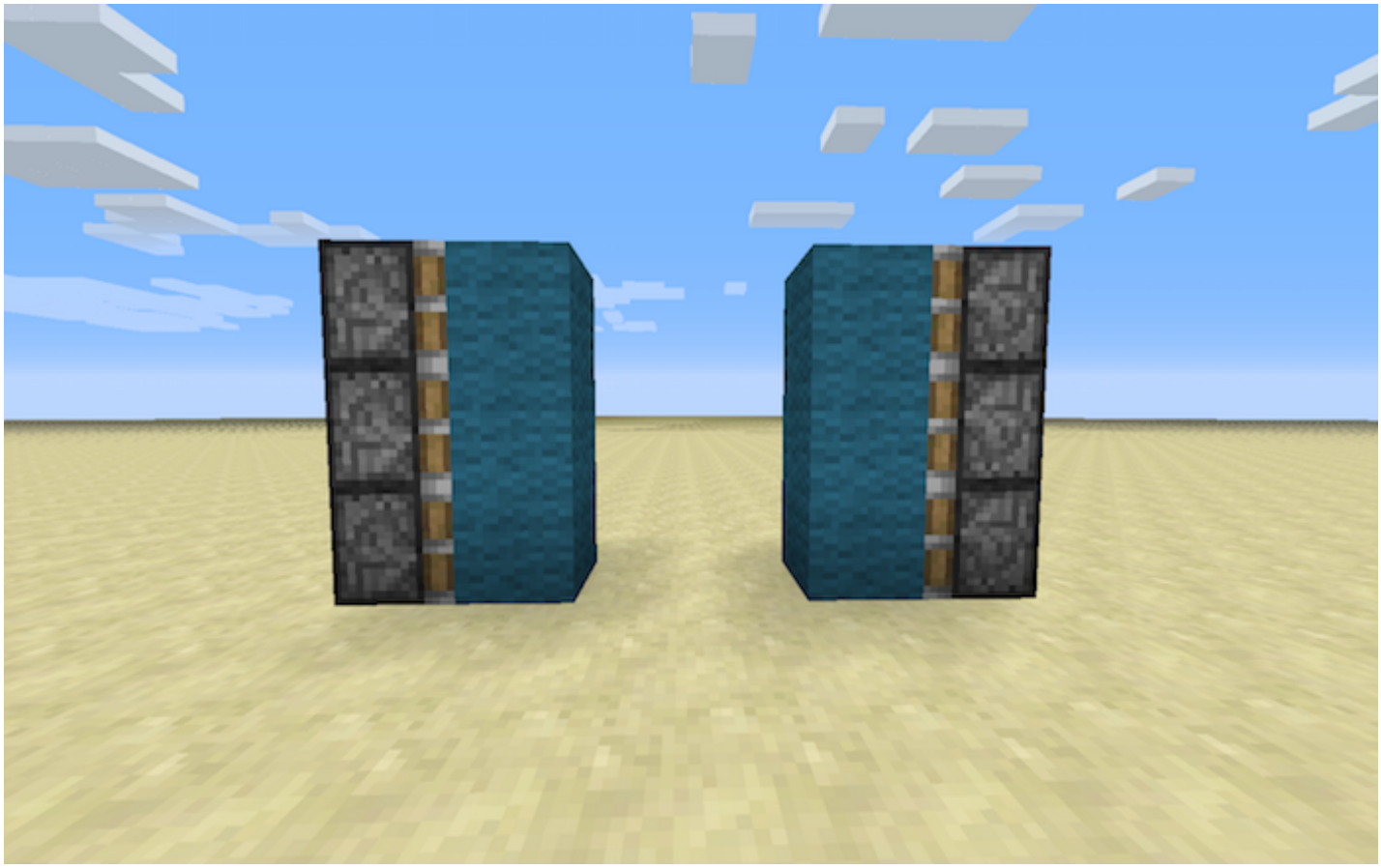
Now that you've seen some of the basics of redstone, experiment more with interactions between redstone and blocks. For example, you could try placing repeaters next to blocks and see how the current behaves.

Section 2: Applications of Redstone Basics

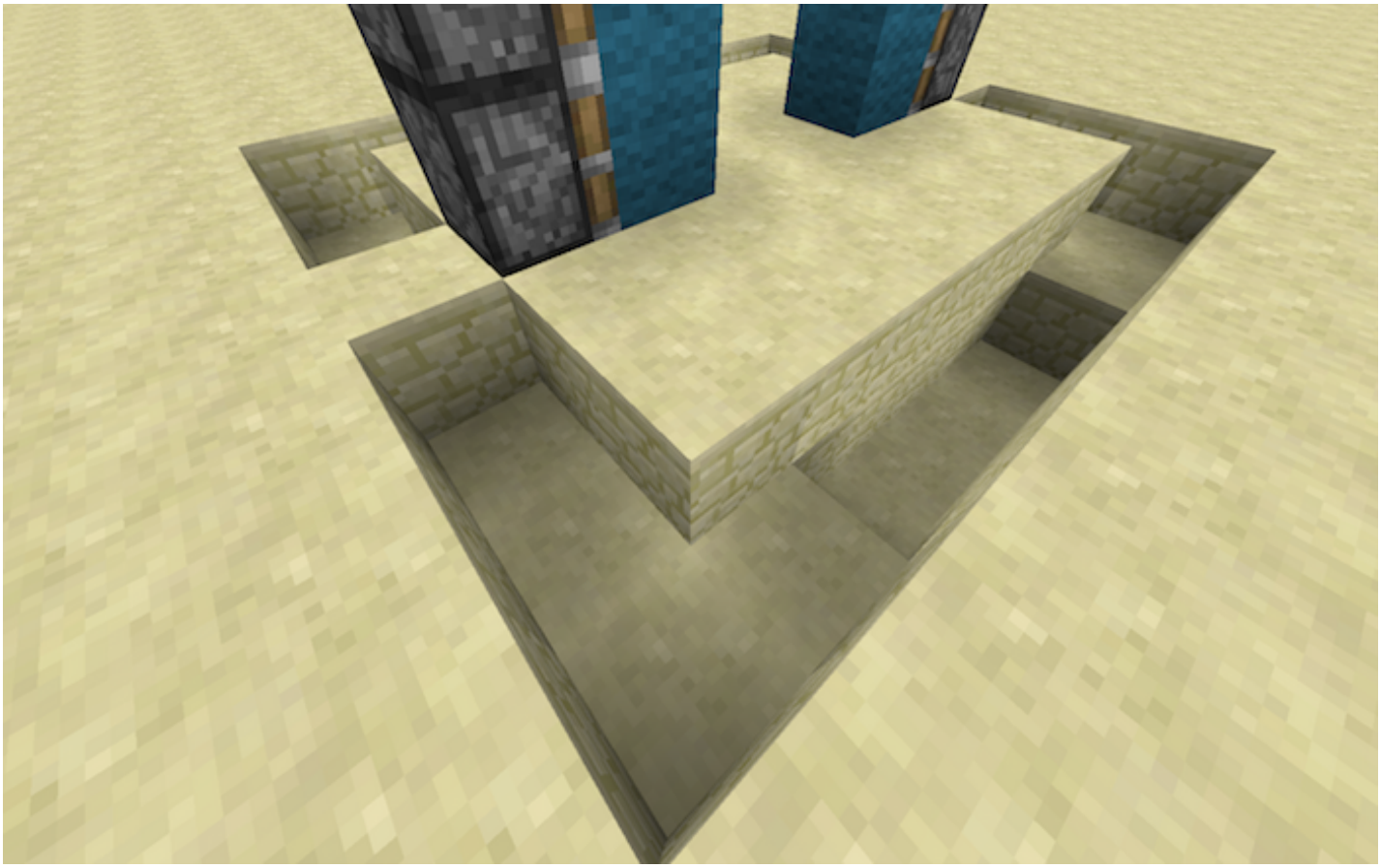
Piston Doors

This section concerns making doors powered by pistons and redstone. Rather than using wood or iron doors, we'll be using pistons to make large doors using blocks. For this you will need redstone, redstone torches, and sticky pistons. Since sticky pistons can both push and pull blocks, they're ideal for making something like a door. The redstone circuit used is simple but still requires some space, which can be hidden inside a wall (especially since doors normally appear in walls!).

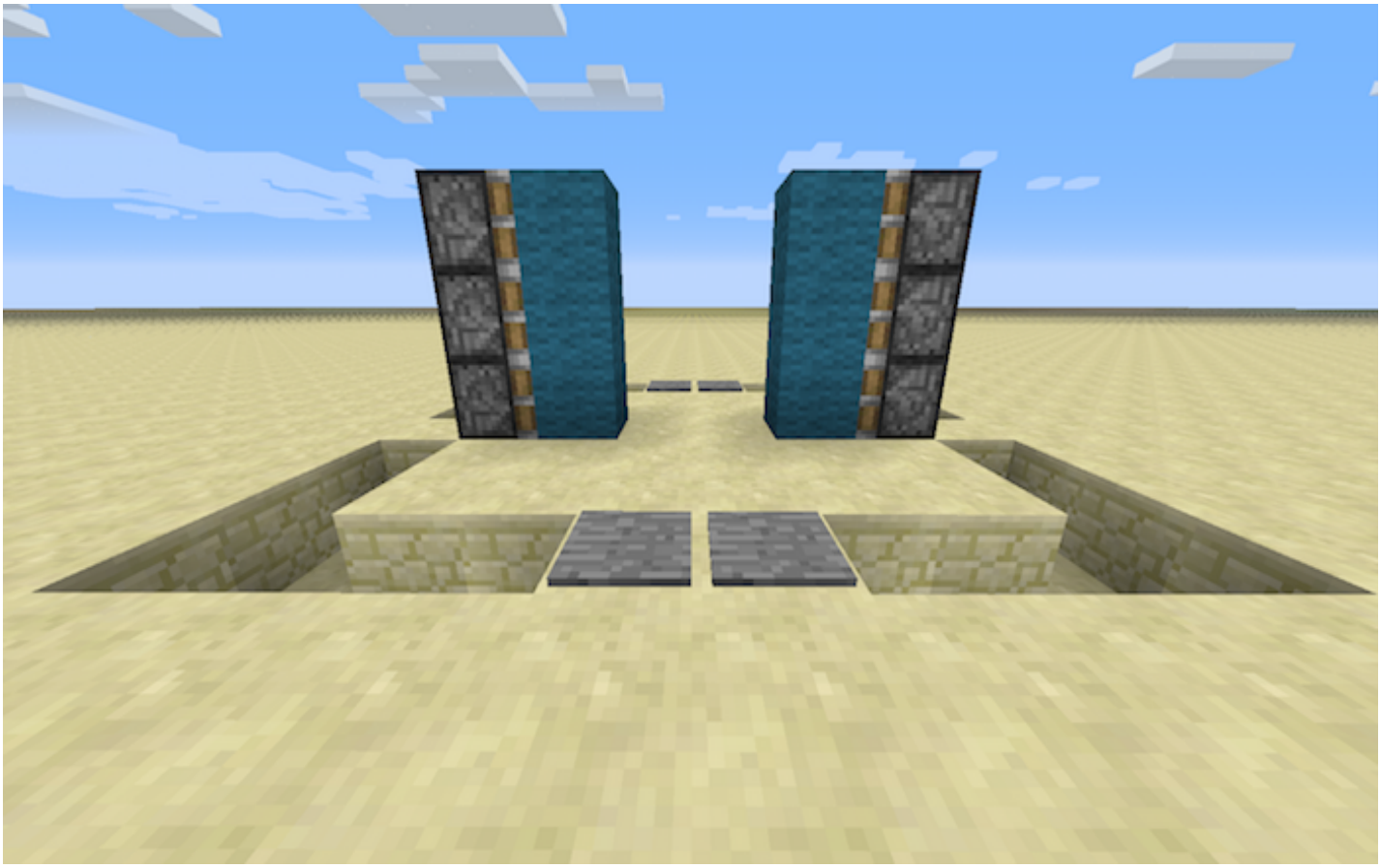
1. The door will be two blocks wide and three blocks tall. Place two columns of three sticky pistons facing each other with four empty air blocks between them. Then place your door blocks (lapiz, gold, etc) onto each of the sticky piston faces. When unpowered, there will be a two-block gap between the pieces of the door.



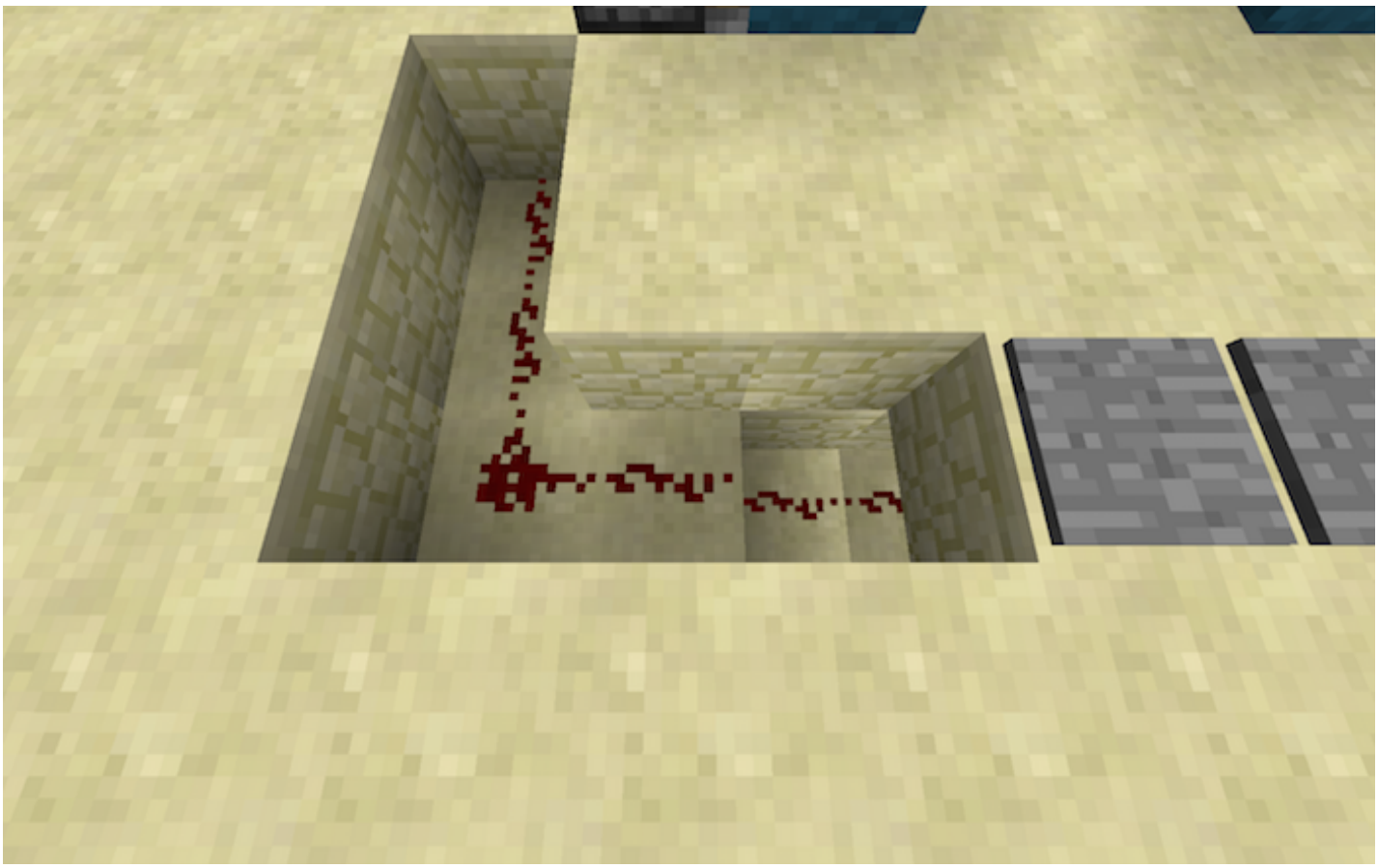
2. Dig a one block deep channel around the doors as shown in this picture. We will hide the redstone we're using to power the doors within this channel. Dig out two more blocks from the front of the door (consult the screenshot if you are confused).



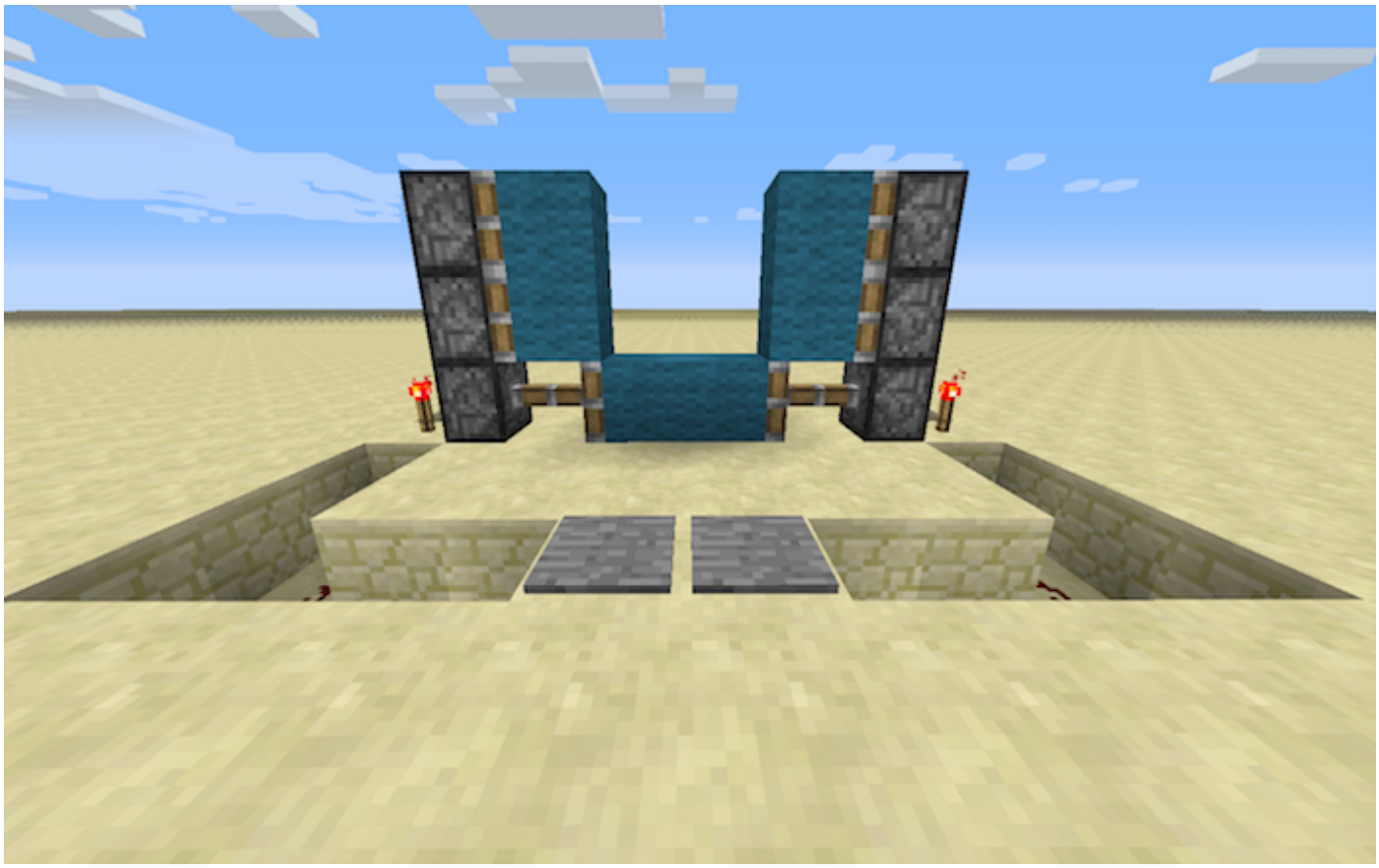
Then put two ground blocks back in the middle (keeping the just-mined block underneath empty) and put two pressure plates on top of them.



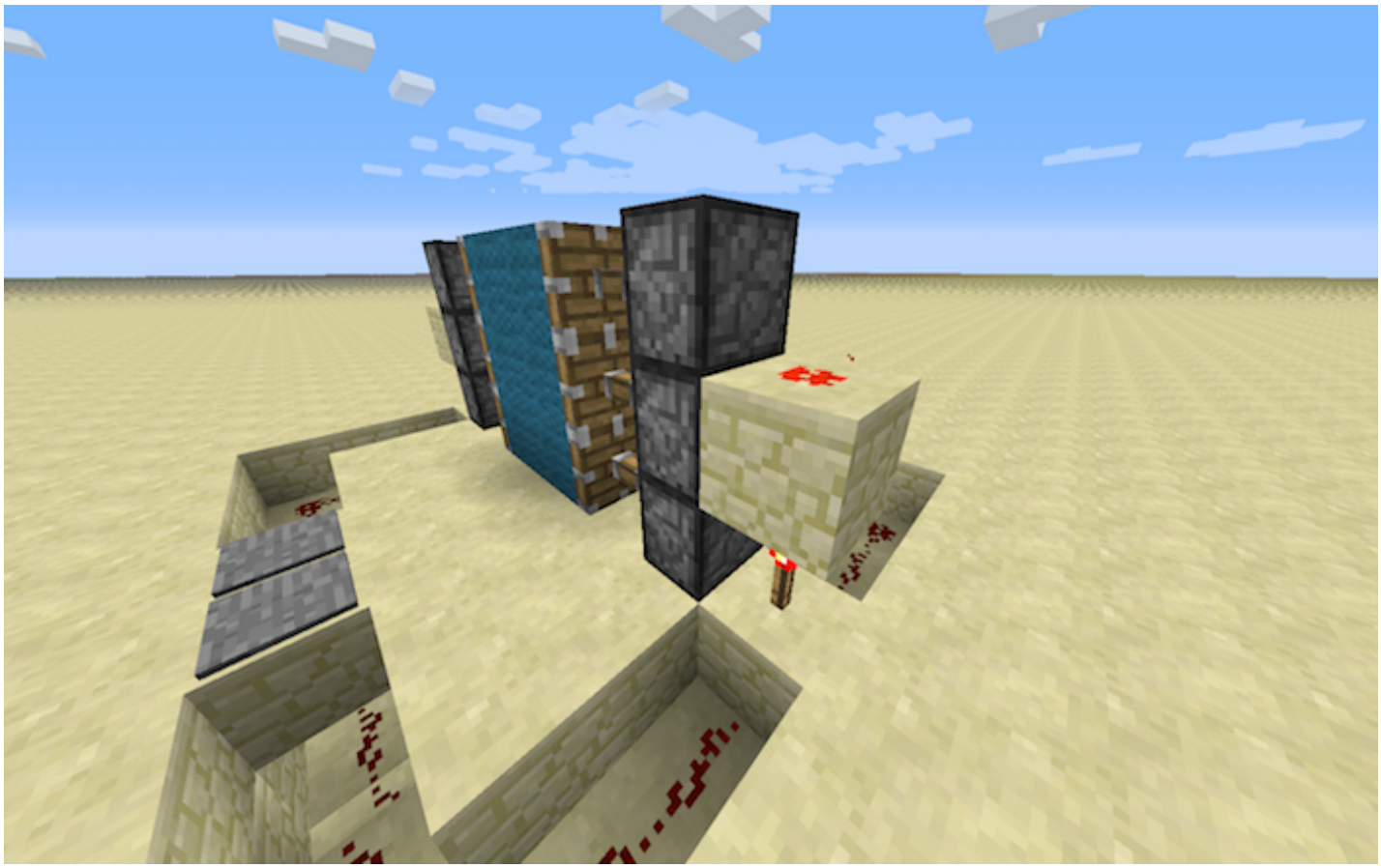
3. Now run redstone from the very bottom space all the way around the bottom of the channel, with the ends pointing into the remaining sandstone block on either side.



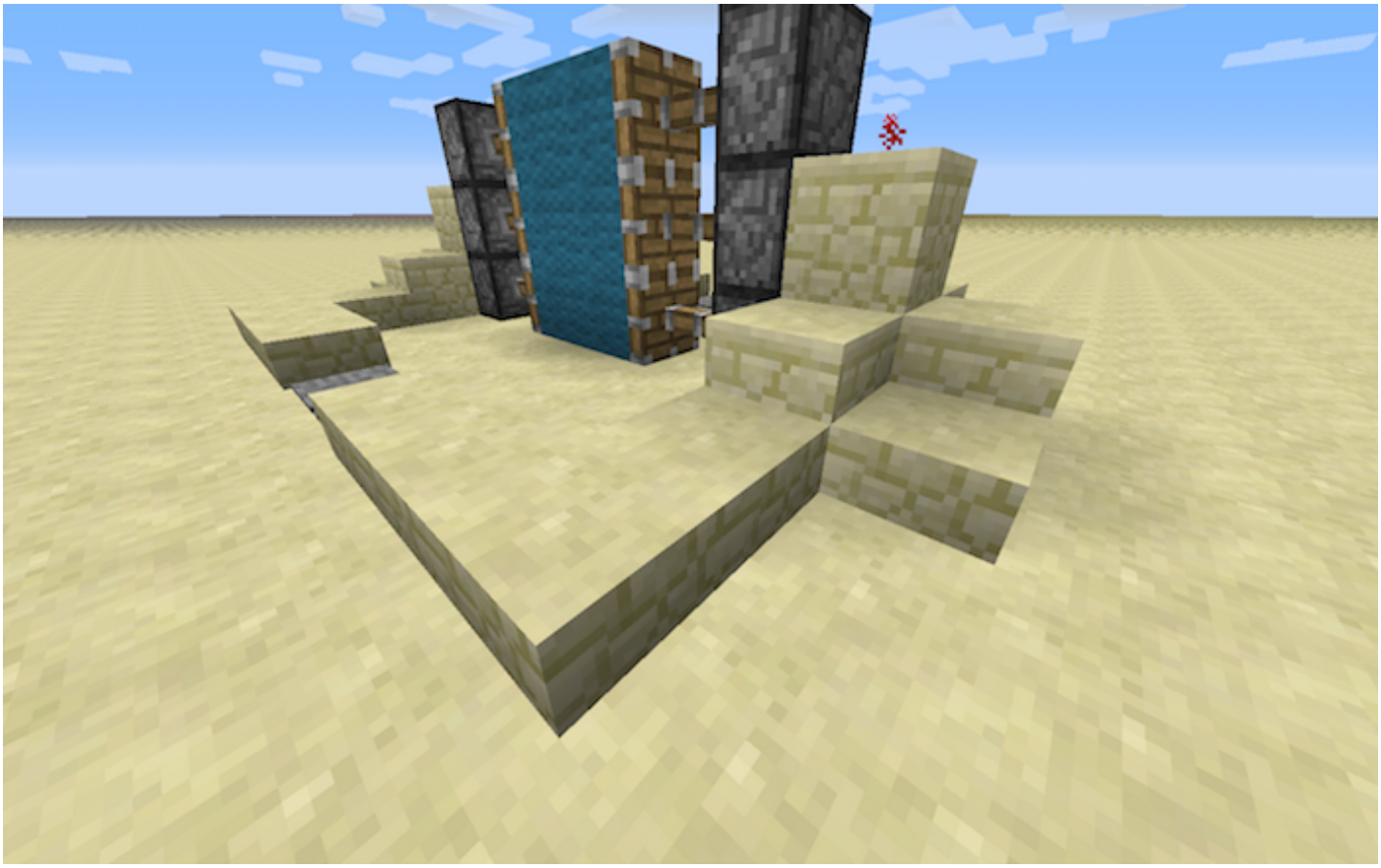
4. Place a redstone torch on top of that remaining sandstone (the torch should be next to the bottom-most sticky piston).



Place a sandstone block on top of that torch and redstone dust on top of that sandstone block. Repeat this for the other side of the door.



5. Cover up the redstone using slabs, which give the best aesthetics. You can also cover up the side towers (pistons and all) with sandstone, wood, or other attractive patterns.

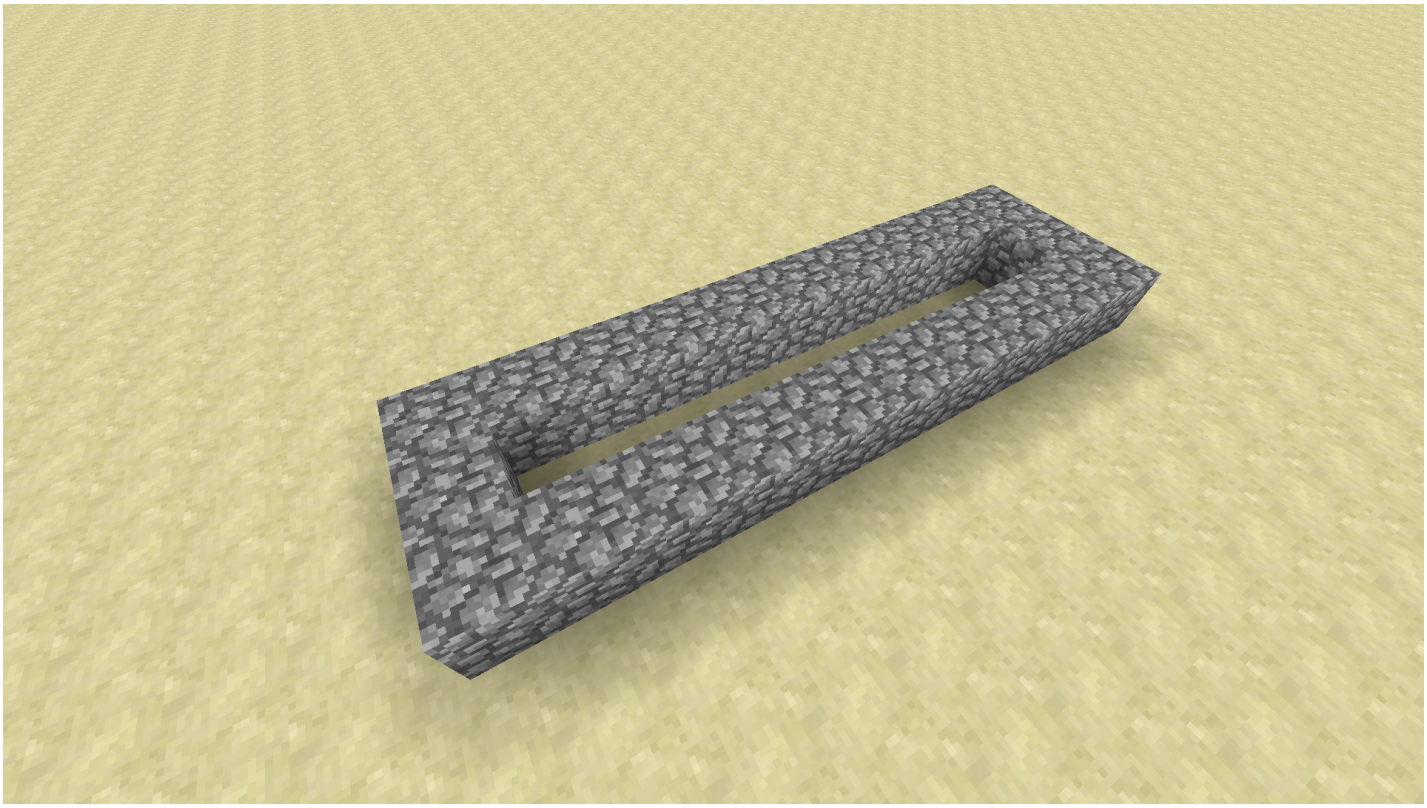


Ultimately, only the two-block space in the middle of the door is what shouldn't be covered. Our suggestion is to build this door as part of a wall where it looks best.

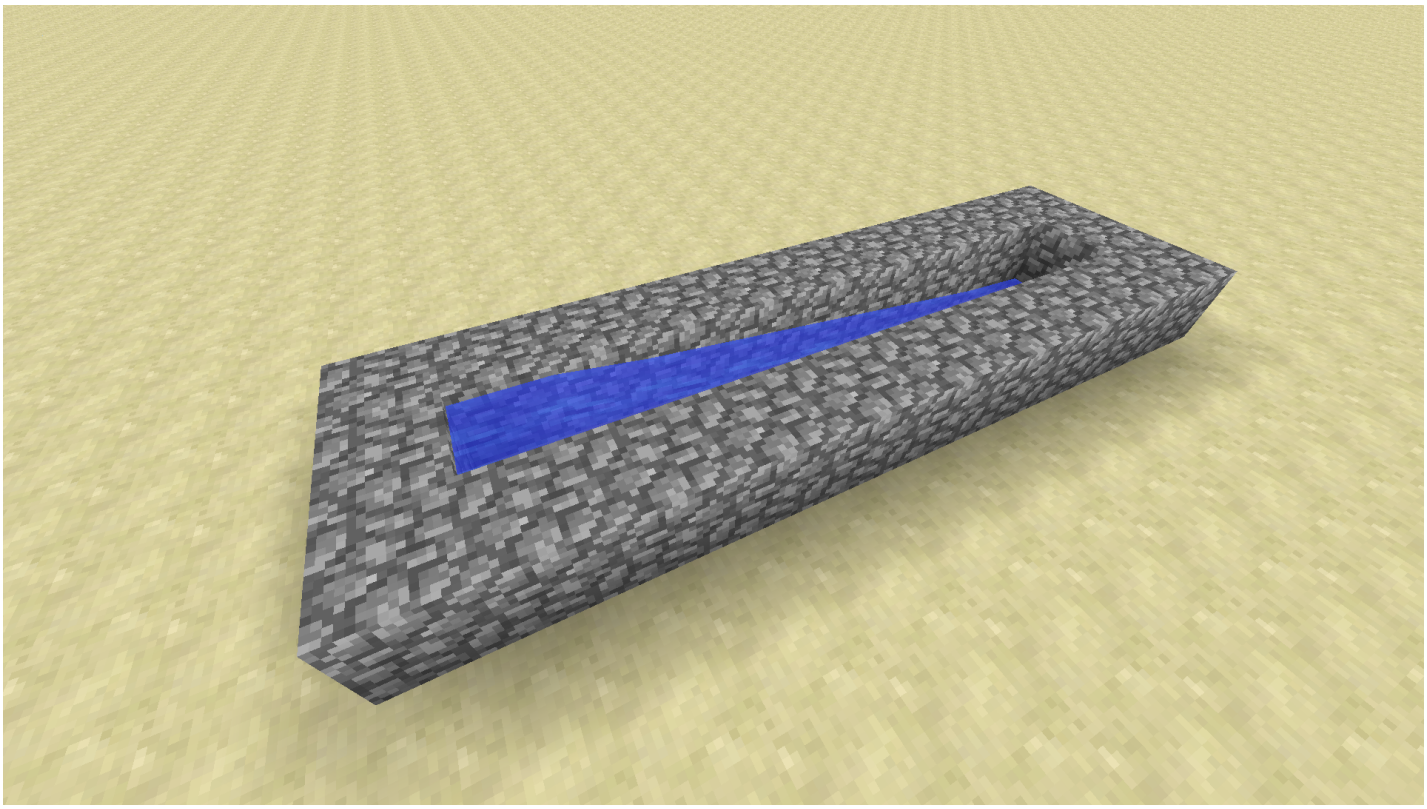
Cannons

By exploiting some of the physics of Minecraft, we can make cannons that fire TNT! As you've probably seen, explosions normally destroy blocks and throw items. Explosions in water, however, will not destroy blocks but will still affect items. Lit TNT is one item that can be thrown, and so we can use TNT and water to shoot a lit TNT block out of our cannon. We will be using redstone to ignite our TNT.

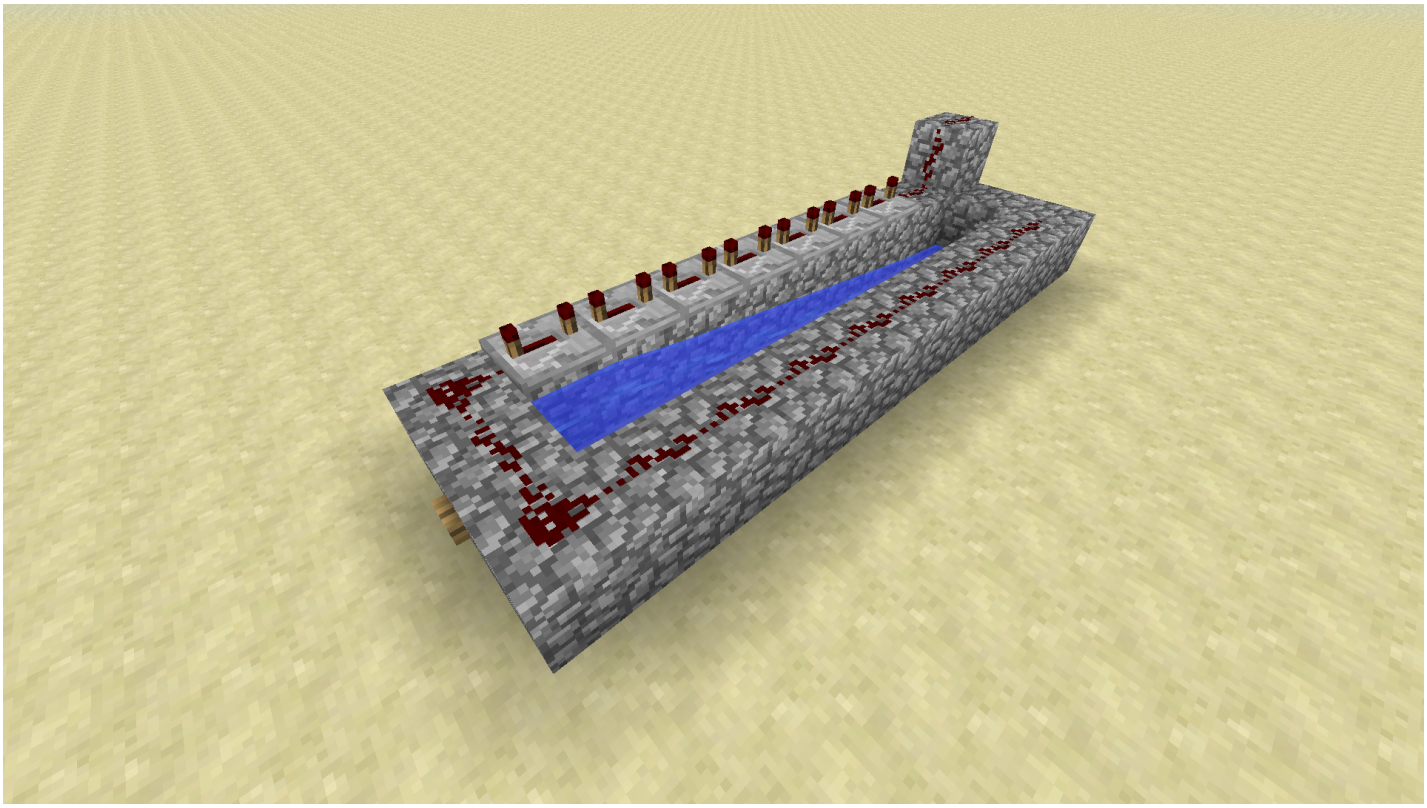
1. Set up the body of the cannon. Cobblestone is what we will be using, though most normal building blocks will work.

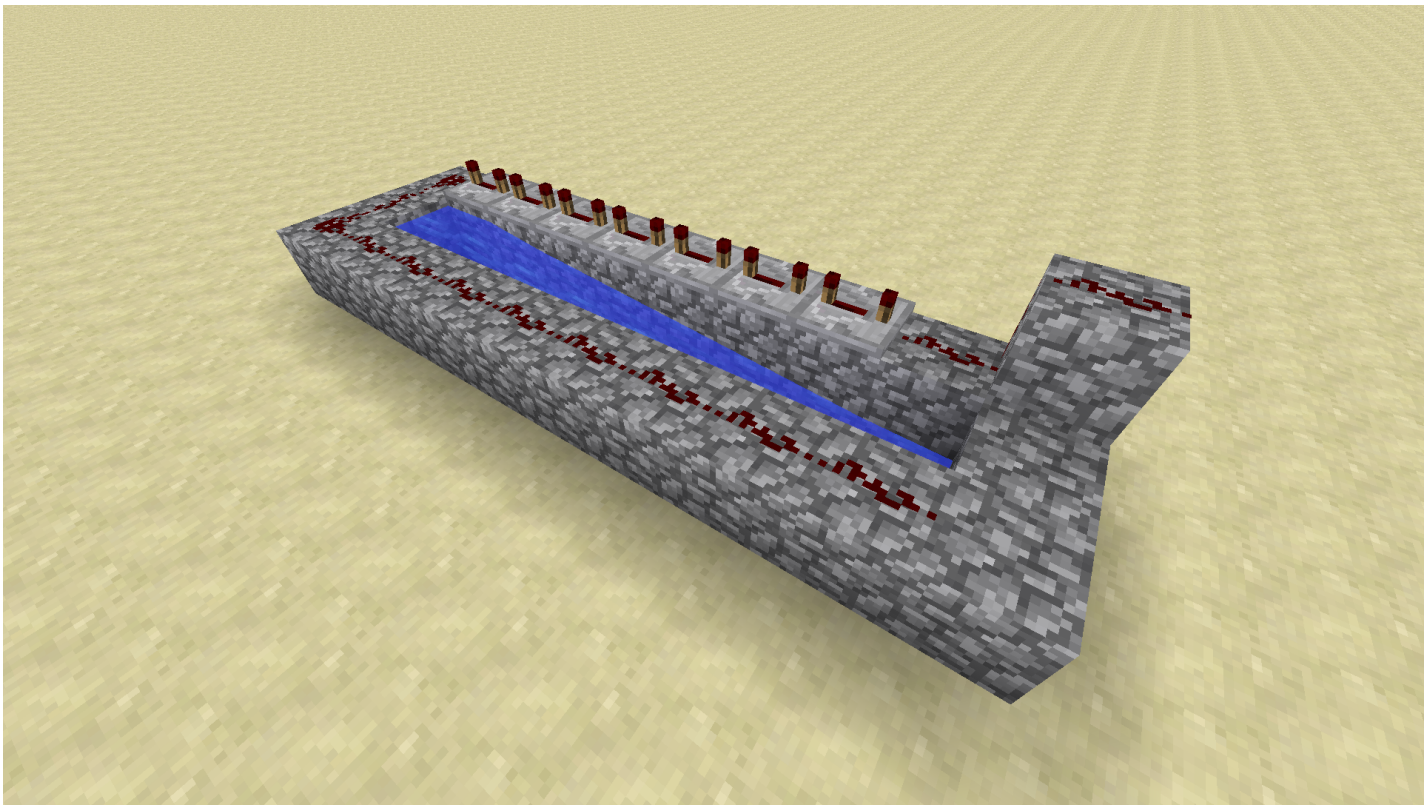


2. Fill the body with water, which will protect the body of the cannon from the blast.

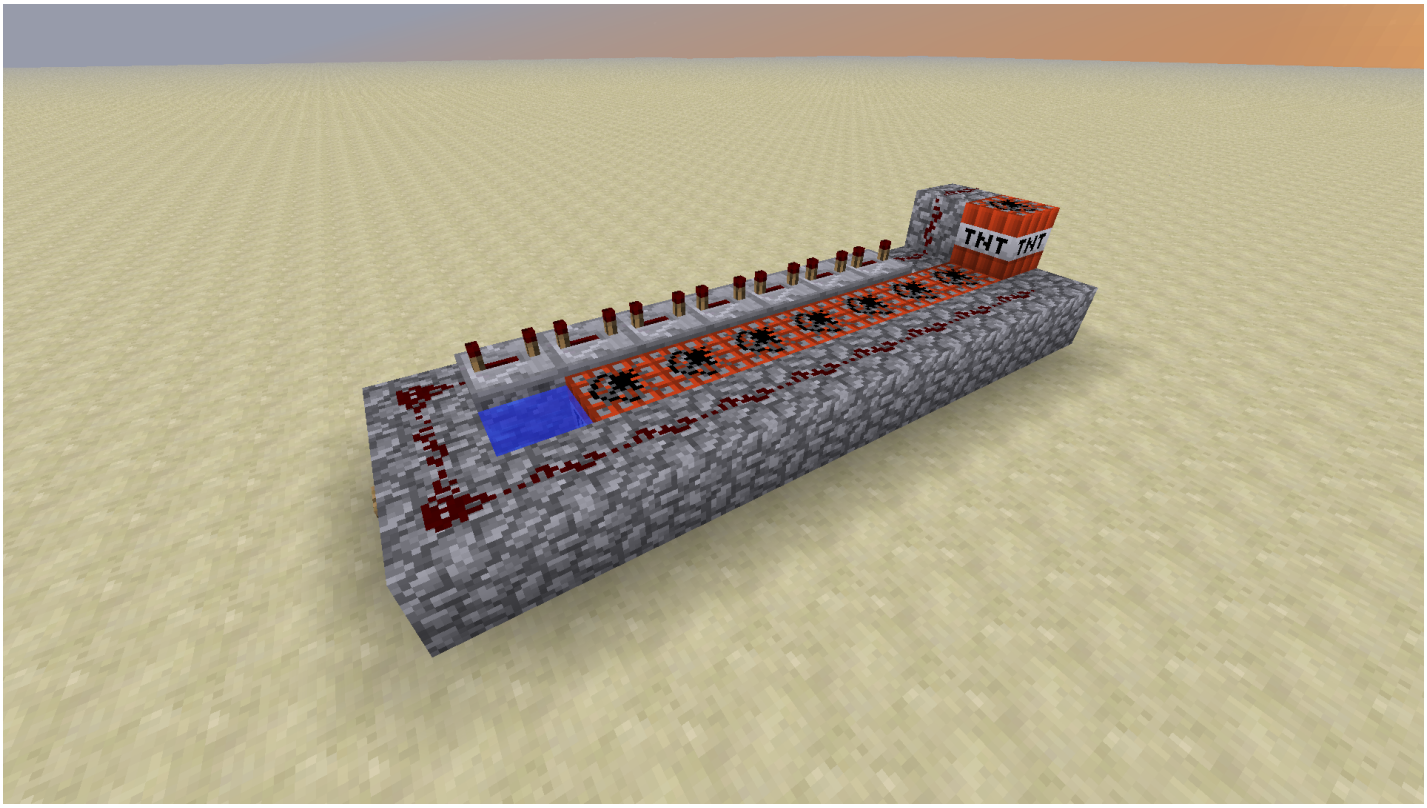


3. Place our redstone and repeaters as well as a button to trigger them. The trail of redstone will ignite our propellant TNT. The repeaters will ensure that the projectile TNT is lit right before it fires.





4. To fire the cannon, we will fill the body with TNT. Be sure not to accidentally place TNT over the source block of water. Then, place the projectile on the very end.

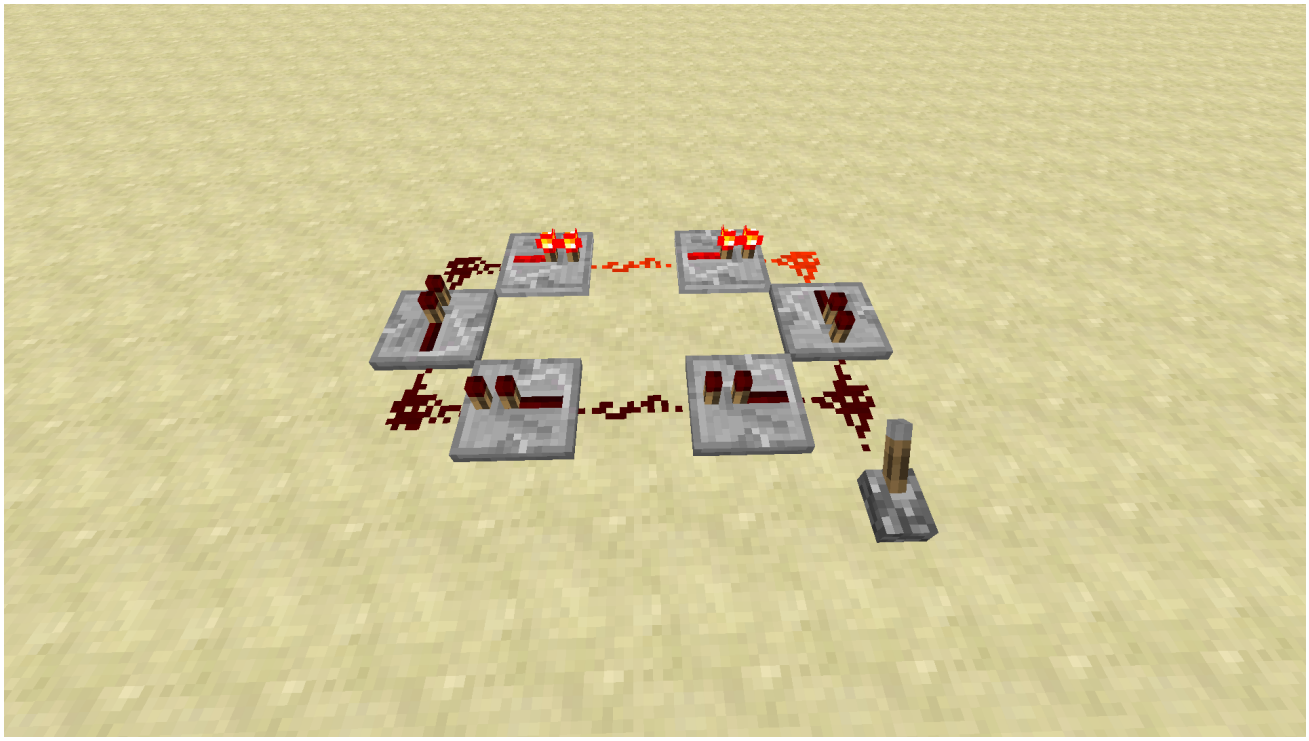


5. Press the button to fire!

We know that we’re limited to using TNT seven blocks away from whatever we want to fire. How could we increase our firing power with this limitation? Come up with some ideas and designs and test them out. Also, experiment with the height of the projectile TNT. How does placing it onto a slab change the distance shot?

Redstone Clocks

Interestingly enough, you can use redstone to make simple clocks in Minecraft. Redstone signals do not travel instantaneously. Instead, they update based on the timing of “ticks”. A “tick” is one update in the world of Minecraft; for redstone, ten ticks occur per second. Generally torches, repeaters, and other blocks take one tick to update. Repeaters are unique in that they can be set to a specific number of ticks; the “setting” on a repeater (moving the torch back and forth along it) changes it to 1, 2, 3, or 4 ticks. So repeaters can be used to make clocks that pulse at a regular rate.

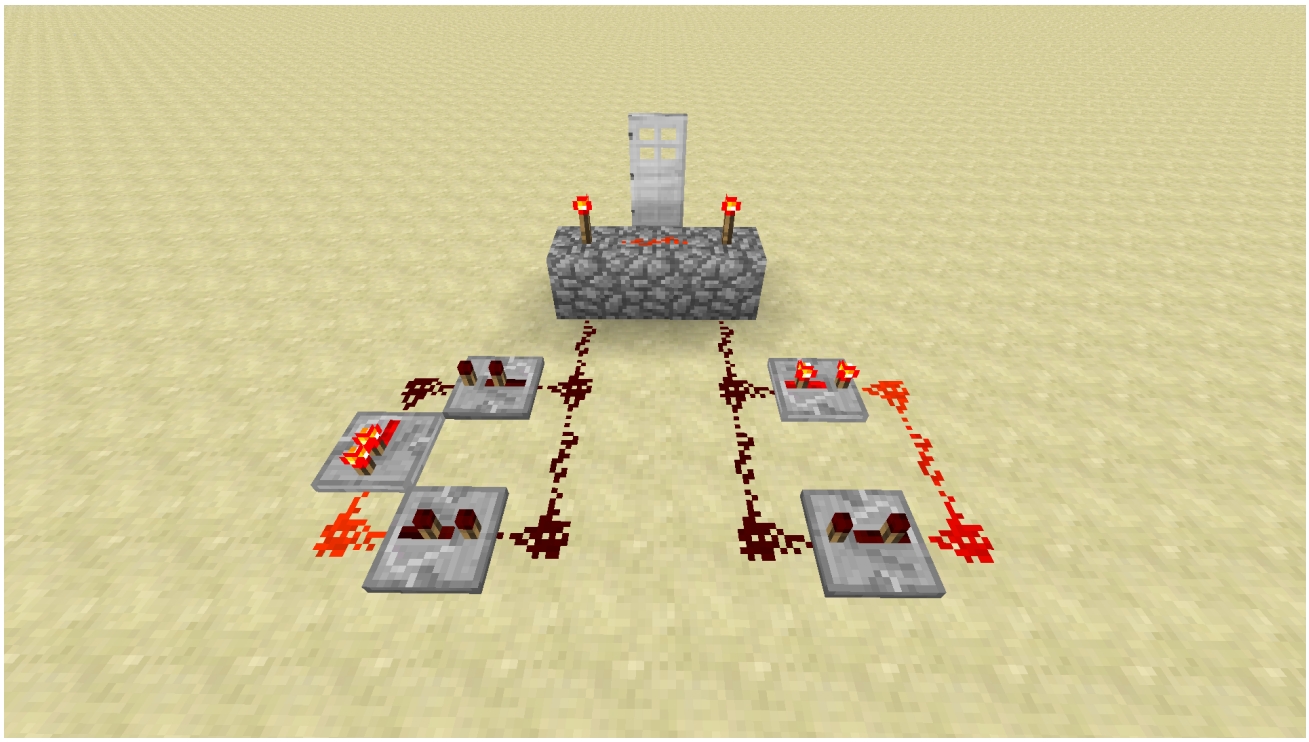


As simple redstone clock made using repeaters.

You can make more complicated clocks by using a simple mathematical principle and something called a logic gate. Let’s say we wanted to make a 30-tick clock, which would pulse every 3 seconds. To use our above design we’d need 8 total repeaters (7 of 4 ticks and 1 of 2 ticks). However, we can actually get away with using just 4 repeaters. To do this, we’re going to make two separate blocks of length 5 and 6. Individually, these clocks only require two repeaters each.

Now, think of the tick numbers that these clocks will pulse on. The first one will pulse at 5, 10, 15, 20, 25, and 30. The second one will pulse at 6, 12, 18, 24, and 30. Both of them will pulse at 30! Since 5 and 6 are both factors of 30, the two clocks will always pulse on multiples of 30. Thirty is the least common multiple (LCM) of the two numbers, and we can use the LCM to make clocks out of far fewer repeaters than with our simple design.

Next, we will use a logic gate called an AND gate. Basically, it’s a series of blocks that takes two redstone inputs. The output will only be ON if the two inputs are both ON. Otherwise, they’ll be off. If we AND the two outputs of our 5 and 6 clocks, the output of that AND will pulse only every 30 ticks, or 3 seconds.



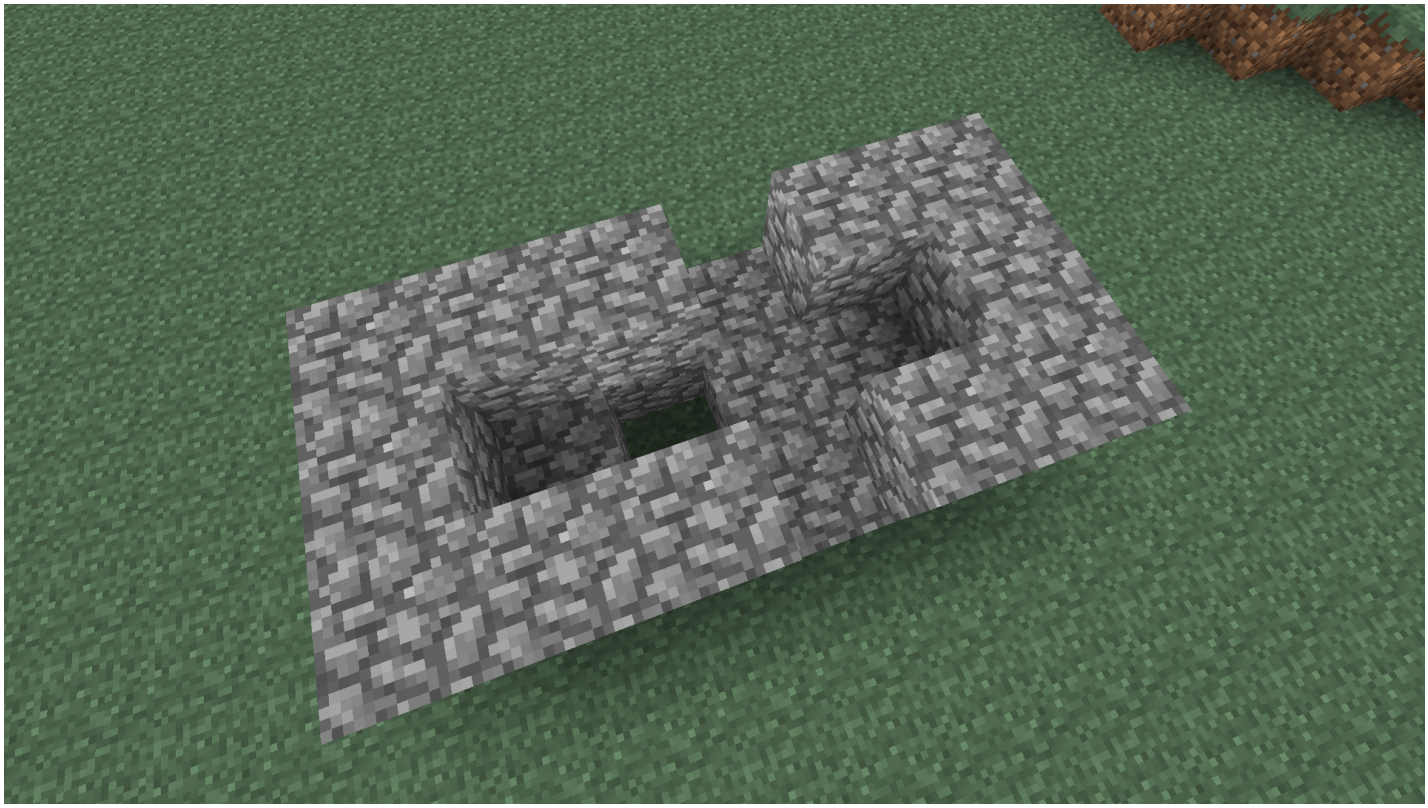
An advanced redstone clock.

Redstone clocks have any number of uses. They can be used to make dispensers output something every set period of time, timers for playing games, or activate pistons for making cobblestone generators. Try to think of some productive uses for redstone clocks and implement them yourself!

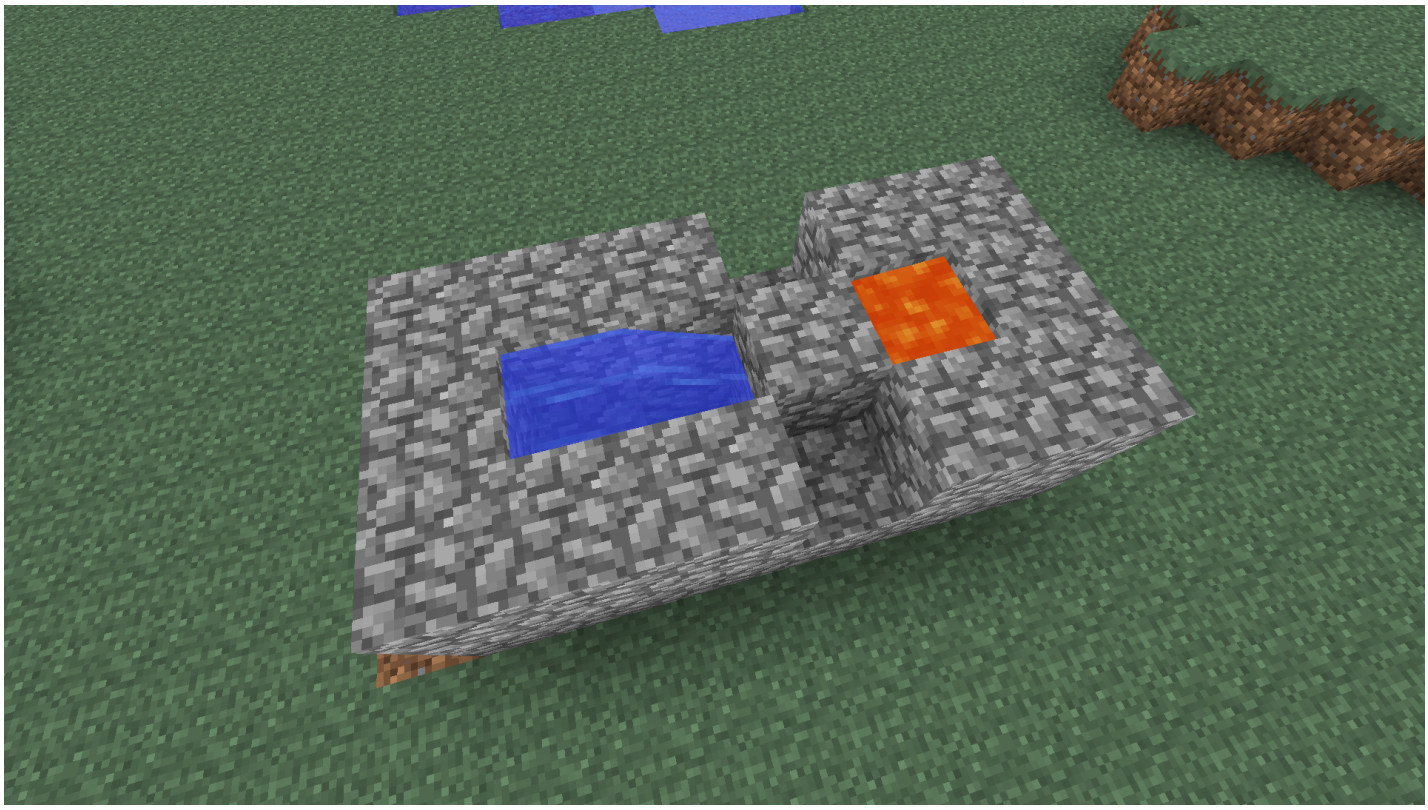
Cobblestone Generator

A cobblestone generator is both less costly and more useful than a TNT cannon. Cobblestone is created when flowing water and lava combine and is a valuable resource, especially on resource-light worlds. By controlling the flow of water and lava and utilizing a piston circuit, we can create a contraption that automatically builds cobblestone for us to harvest.

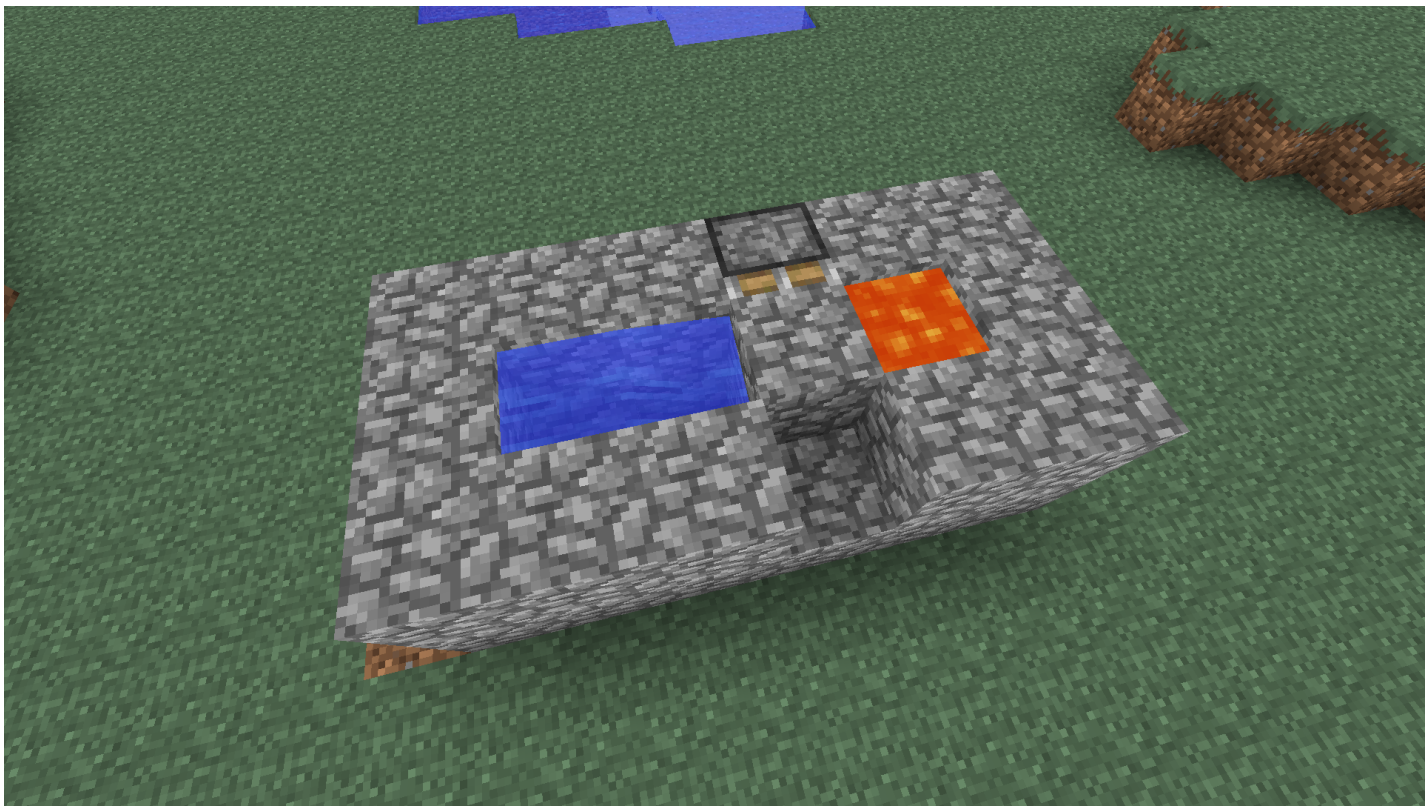
1. Build the body of the generator. Be sure to include the hole in the middle, as without the hole water would flow over the lava source block and turn it into obsidian.



2. Place the water and lava source blocks from a bucket. Notice how cobblestone is formed in the middle!

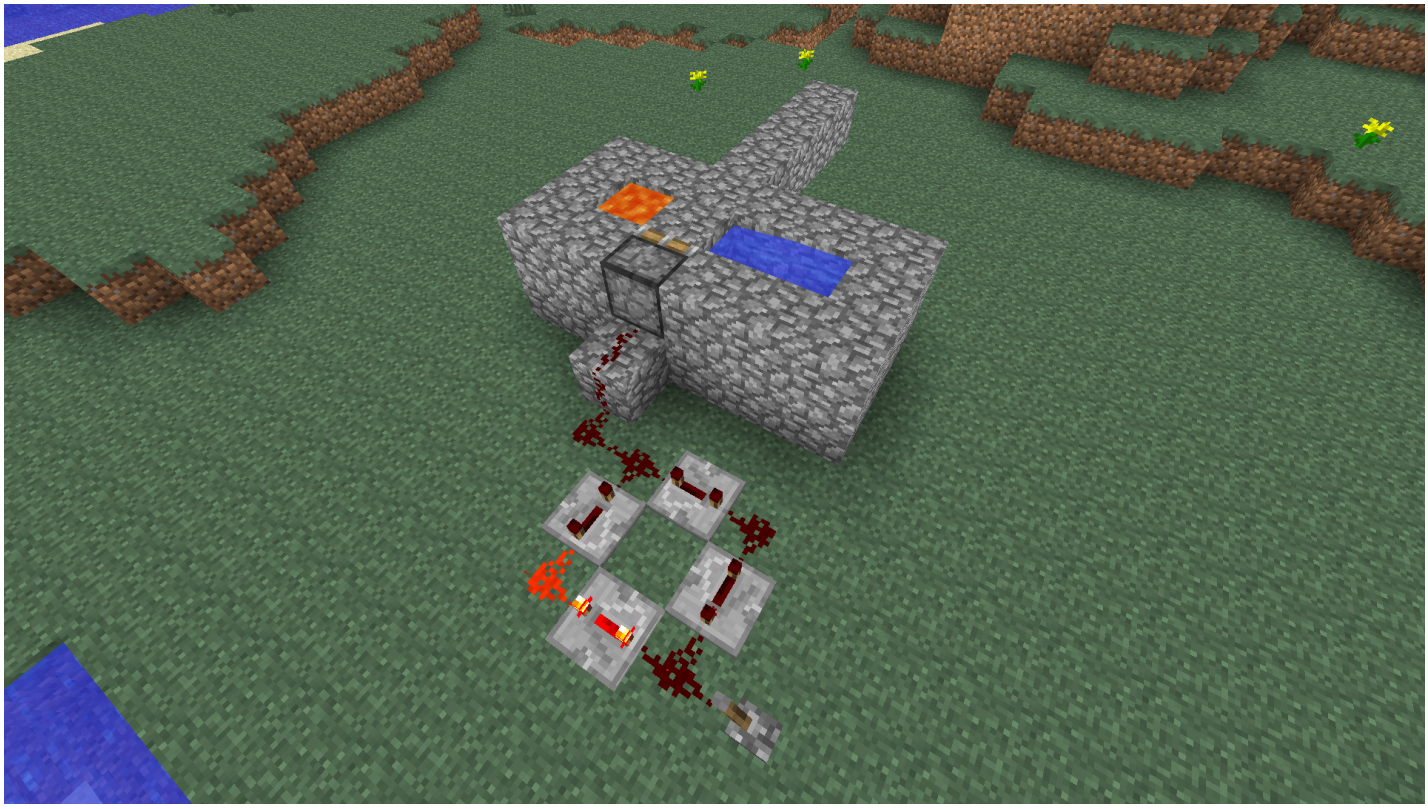


3. Place the piston that will push out the cobblestone blocks.



4. Create the redstone circuit that will cause the piston to automatically extend and then retract. We'll be talking about redstone clocks later in the lesson, but this one is simple enough that we can make use of it right now.

5. Quickly flip the lever on and off to start the generator. Pistons will push up to 12 blocks before stopping, but if you keep mining out the cobblestone column this generator will run forever.



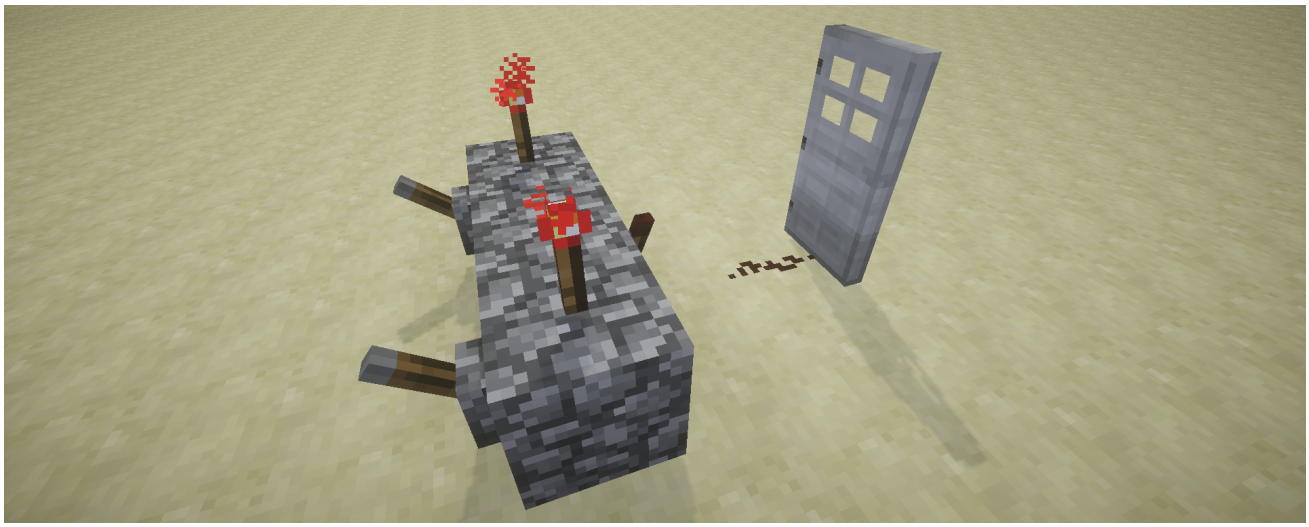
Section 3: Logic Gates

Logic Gates are a fundamental building block for digital circuits. They perform *boolean* functions and usually have 2 inputs and 1 output

AND

The AND gate performs the AND logic function which mathematically works like multiplication.

In Minecraft, your AND gate will take two redstone inputs which will either be ON or OFF. The output depends on the combination of inputs.



An example of an AND gate.

ON AND ON => ON
ON AND OFF => OFF
OFF AND ON => OFF
OFF AND OFF => OFF

Try these out on the above gate and see what happens. Remember that a lever is OFF if it is pointed upward.

Truth Tables

Truth tables are an easy way for us to organize the various outputs of logic gates given different inputs.
For boolean logic, “ON” is replaced with “True” or “1” and “OFF” is replaced with “False” or “0”. For example, the AND Gate could look like this:

TRUE AND TRUE => TRUE
TRUE AND FALSE => FALSE
FALSE AND TRUE => FALSE
FALSE AND FALSE => FALSE

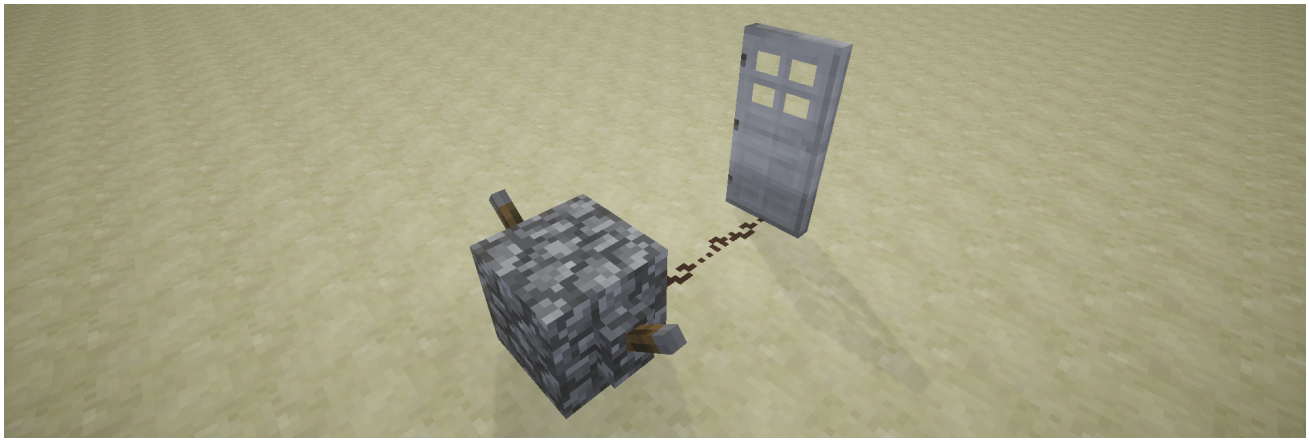
Which is the same as:
1 AND 1 => 1
1 AND 0 => 0
0 AND 1 => 0
0 AND 0 => 0

We can simplify this further to just a table:

Input	Input	Output
1	1	1
1	0	0
0	1	0
0	0	0

OR

The OR gate will only output OFF if both inputs are OFF. If either input is ON or if both are ON, the output will be on.

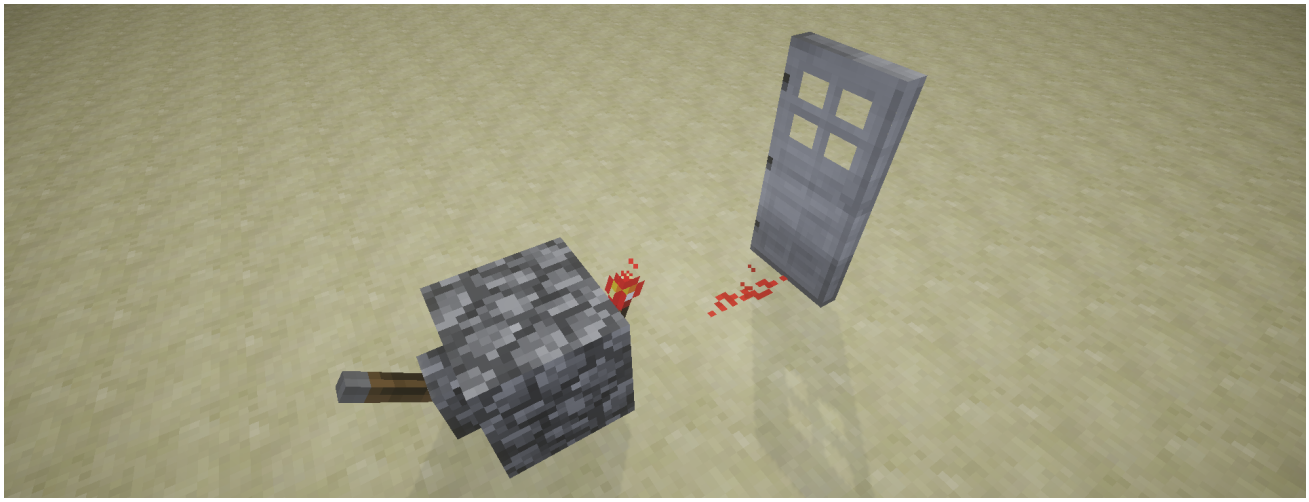


An example of an OR gate.

Input	Input	Output
1	1	1
1	0	1
0	1	1
0	0	0

NOT

A NOT gate only has one input and simply reverses that input. An ON input leads to an OFF output, and vice-versa.

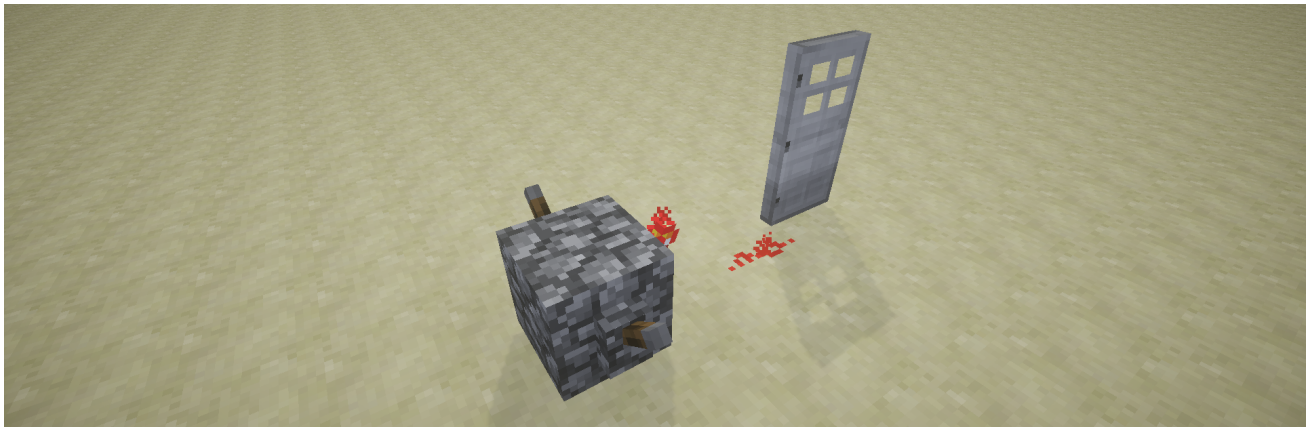


An example of a NOT gate.

Input	Output
0	1
1	0

NOR

A NOR gate is just an OR gate with its outputs reversed. So a NOR gate will only output ON if both inputs are OFF. Otherwise the output is OFF.

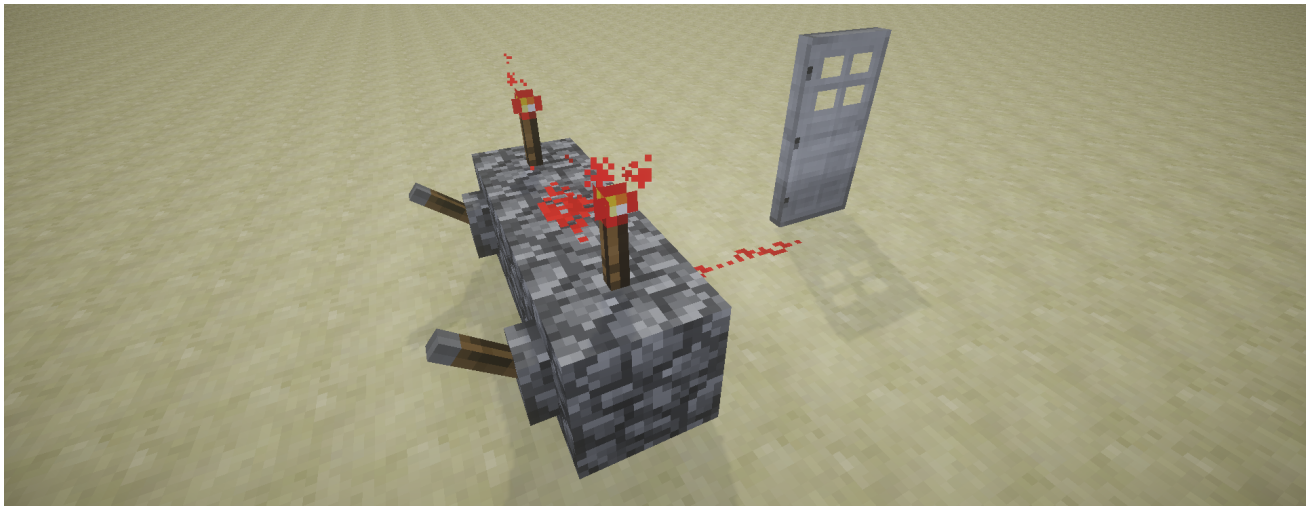


An example of a NOR gate.

Input	Input	Output
1	1	0
1	0	0
0	1	0
0	0	1

NAND

Just as a NOR gate has the opposite outputs of an OR gate, a NAND gate has the opposite outputs of an AND gate. It will output OFF only if both inputs are ON. If either input is OFF, the output will be ON.

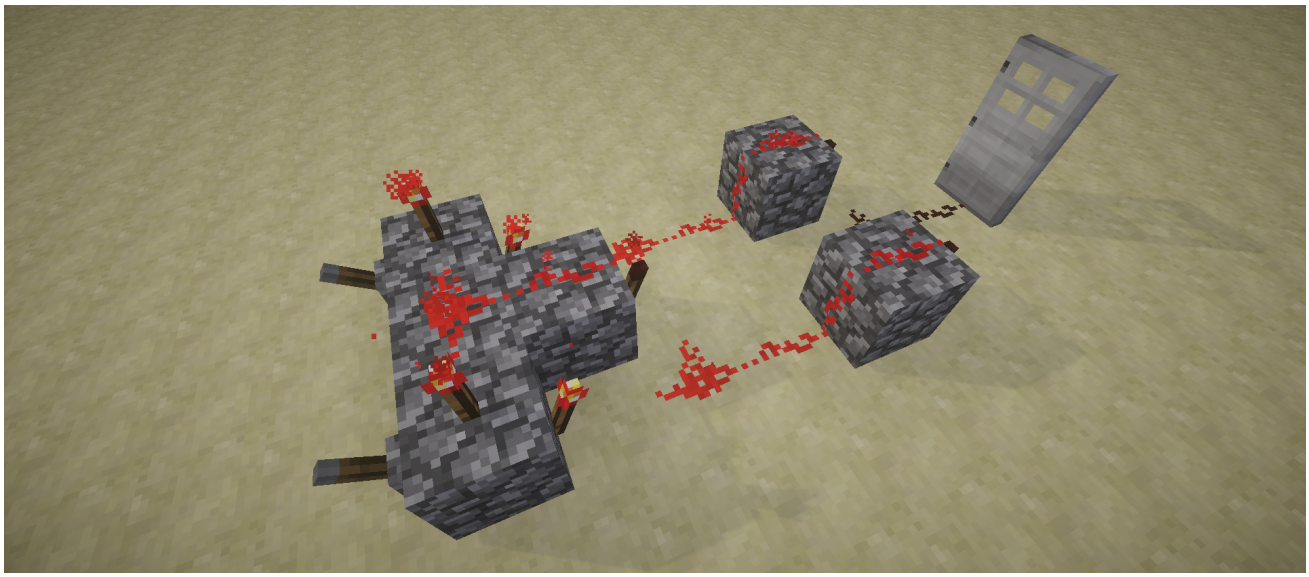


An example of a NAND gate.

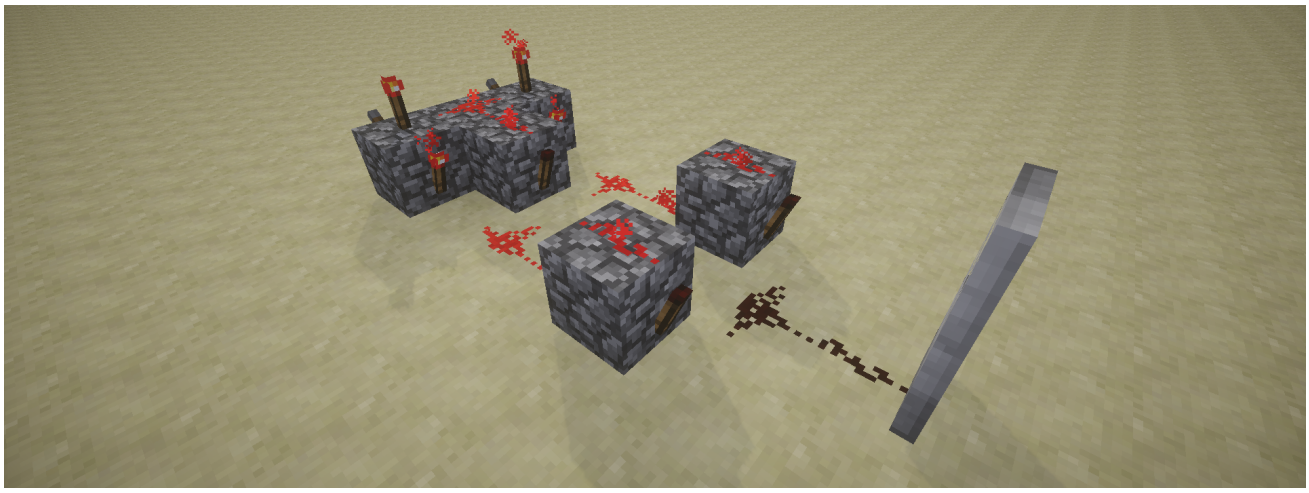
Input	Input	Output
1	1	0
1	0	1
0	1	1
0	0	1

XOR

An XOR (ex-or) gate is also called an “exclusive OR” gate. It will only output ON if either lever is ON. If both levers are either off or on, it will output OFF.



An example of an XOR gate.



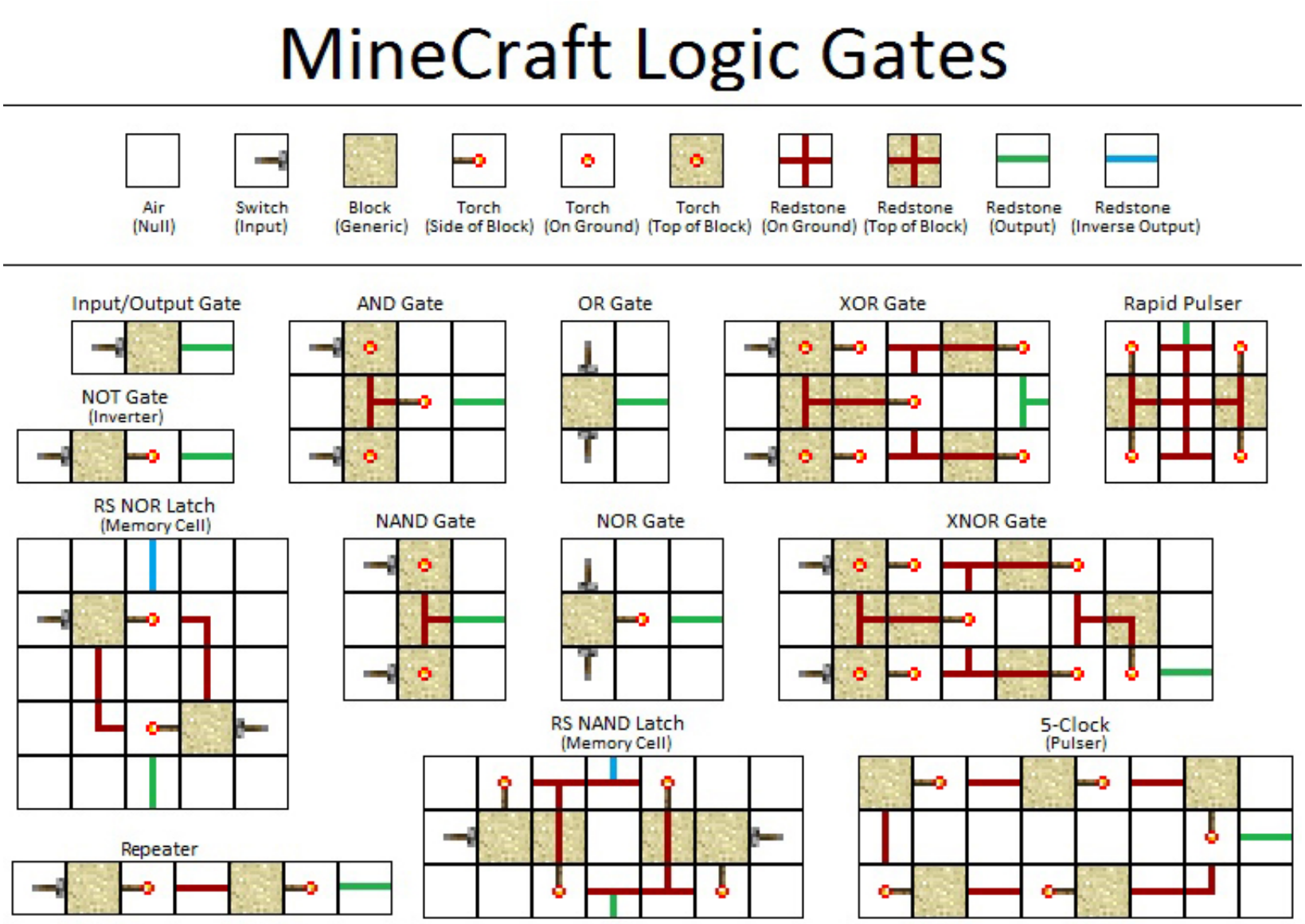
A different perspective of the same gate.

Input	Input	Output
1	1	0
1	0	1
0	1	1
0	0	0

Reference

This diagram has most of the logic gates that we've gone over, as well as some more that you may find useful.

A diagram with redstone gate examples.

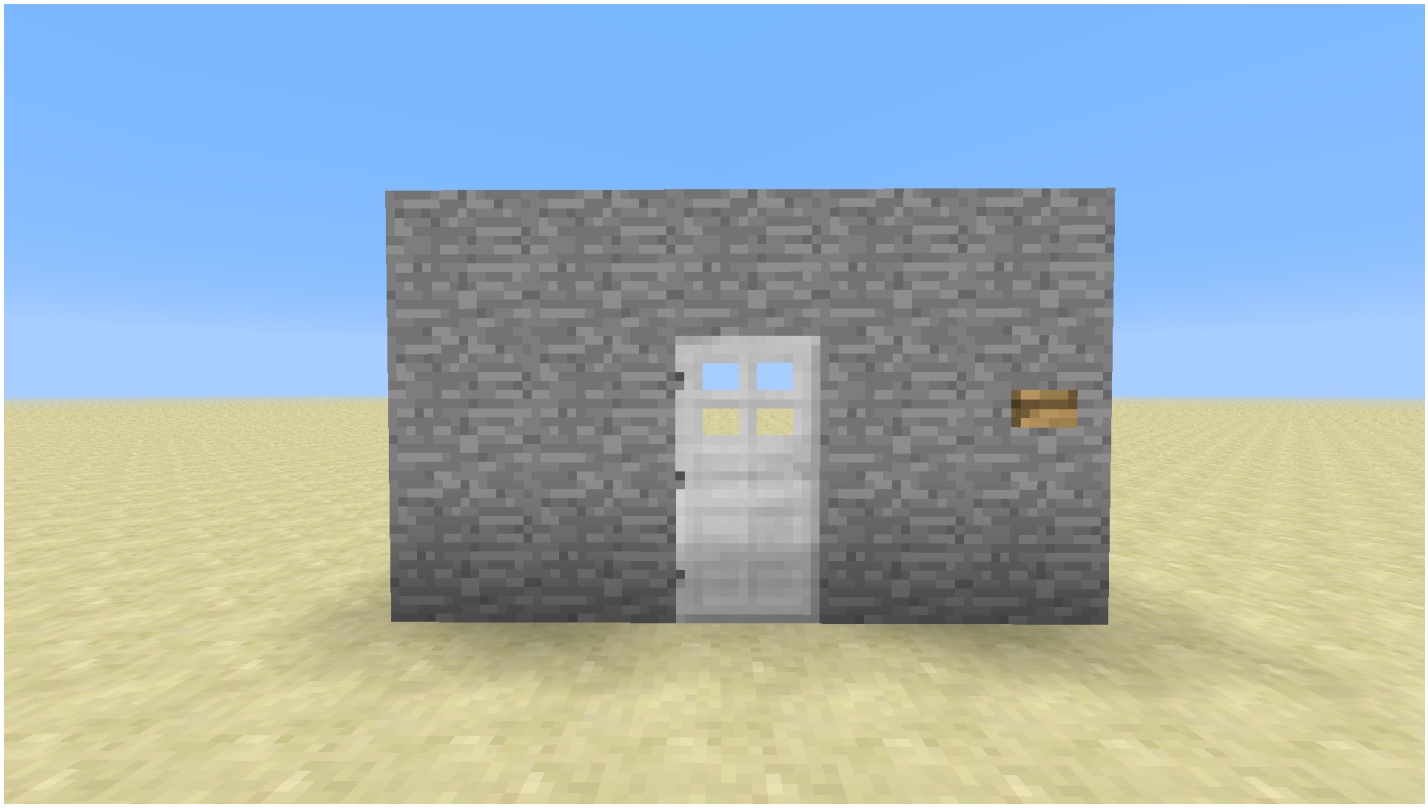


Section 4: Applications of Logic Gates

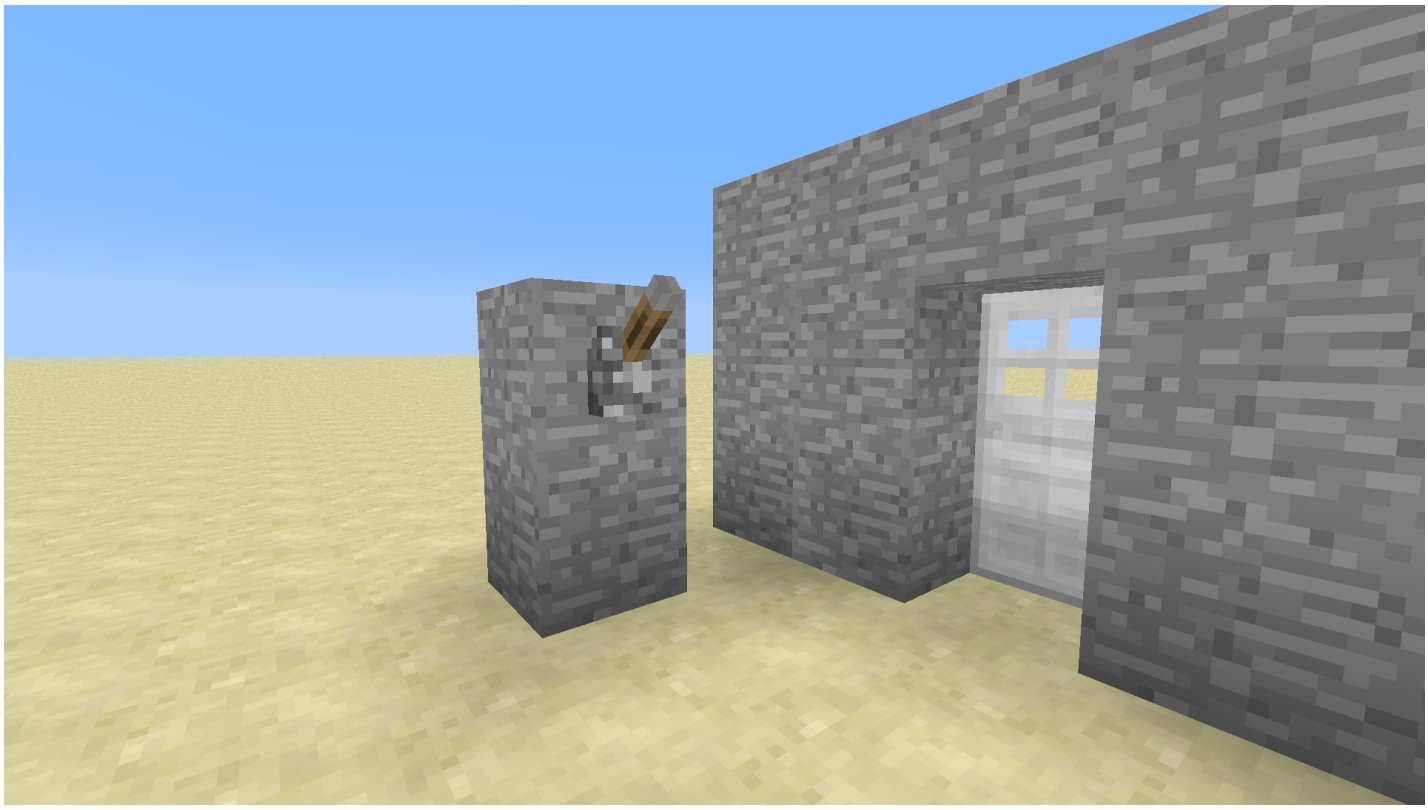
Locked Doors

Sometimes you may want to prevent people from entering a door using a lock. By having a lever on the inside, you can prevent the door from being opened unless the lever is in a specific state.

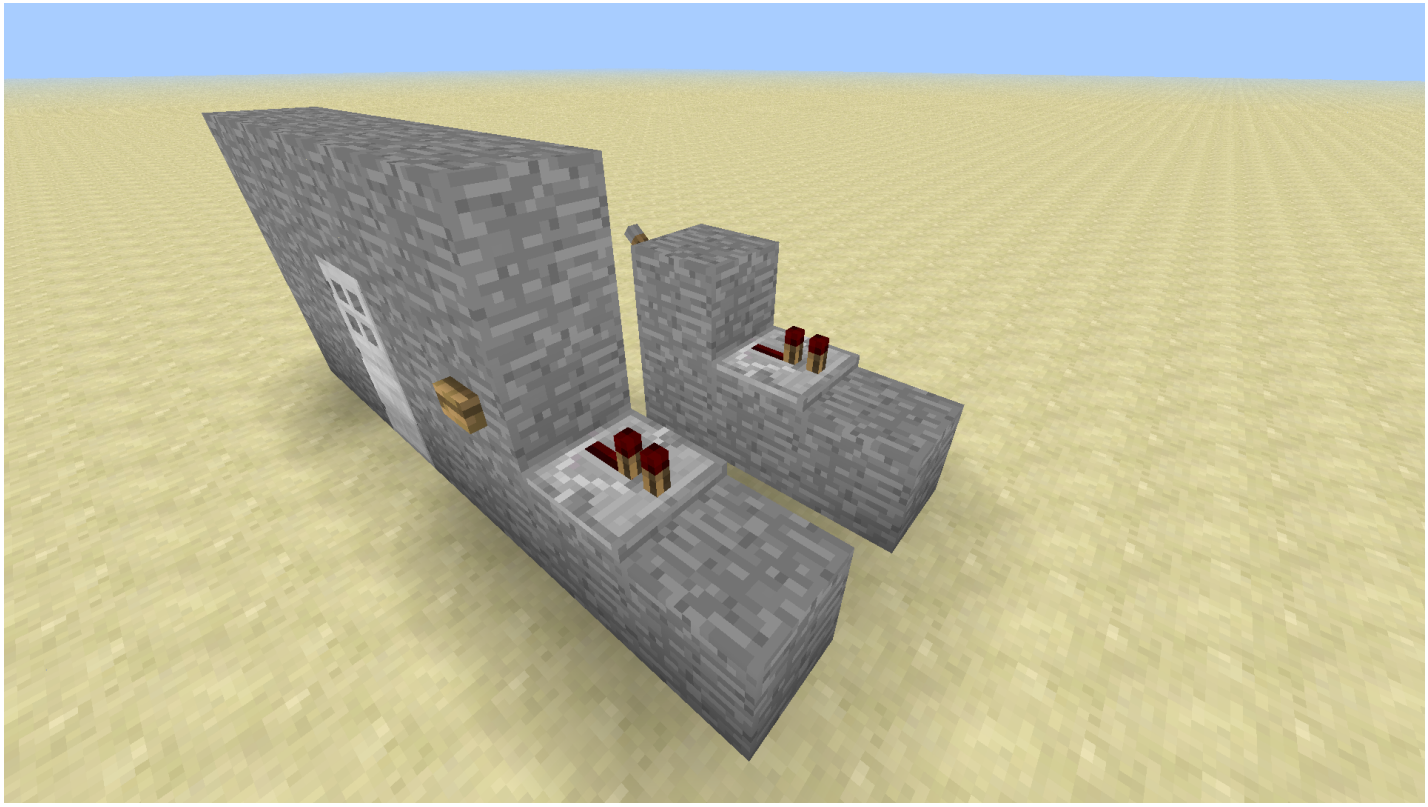
1. Place a door and build a wall around the door. A button should be placed one block away from the door; its block cannot be touching the door or it will open the door every time.



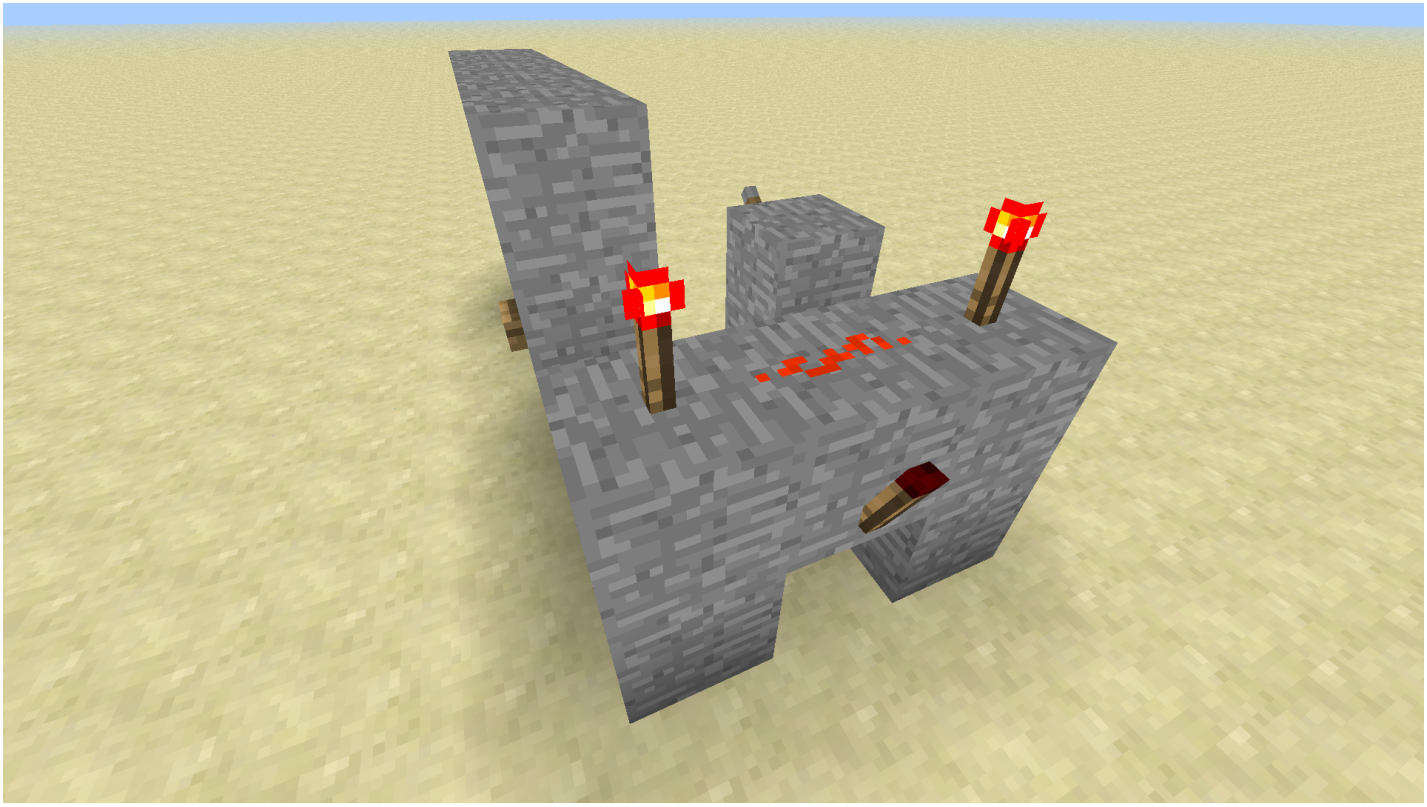
2. The location of the lock lever inside the door.



3. Repeaters that carry the redstone signal from both the button and the lever. Be sure to place the layer of stone underneath them so they are powered by the button and lever.



4. An AND gate. The two inputs are the lever and the button, and the output goes to the door. The output will only be ON when both the button and lever are ON as well.



5. The redstone that carries the output of the AND gate to the block directly underneath the door. Now, the door will only open when the lever is set and the button is pressed.