

Instructions for turning the *Lego Grand Piano* into *The Playel*, a fully MIDI-compliant keyboard

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Version 1.1

Related performance video: <https://www.youtube.com/watch?v=R0Pd31UHVzw>

Related scientific journal article: <https://ieeexplore.ieee.org/document/10494755>



Preparing the brick model and additional components

First, you need to build the brick model of the original *Lego Grand Piano* [1].

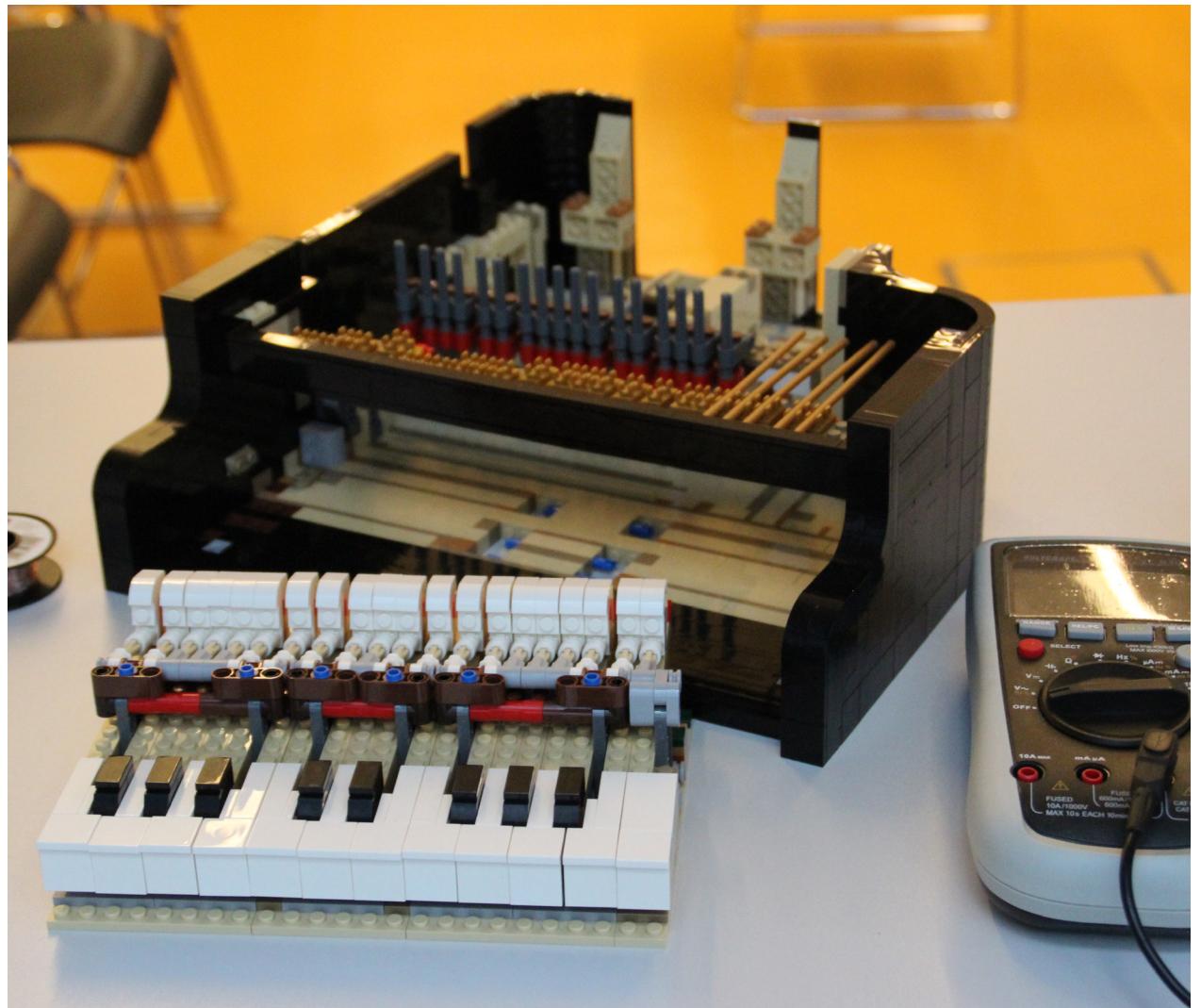
The only mandatory additional Lego parts needed are 25 *Technic pins 1/2* to fix the wires on each of the 25 keys (Fig. 2g), which you can get easily from a brick reseller, for instance *Bricklink* [2].

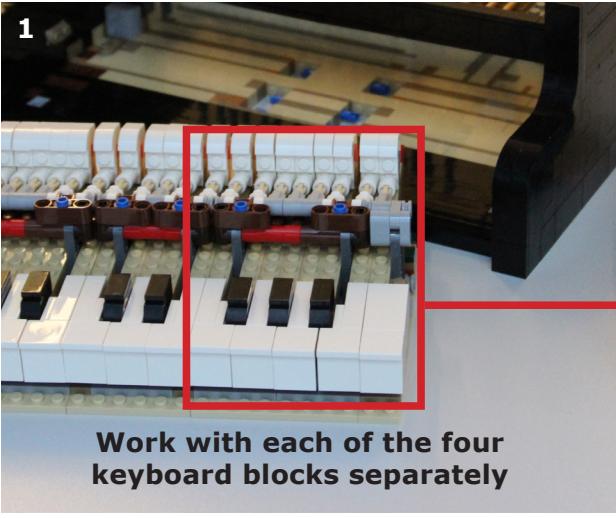
Two *Technic bricks* with 1x16 studs (15 holes) or other lengths and combinations of shorter and longer *Technic bricks* are recommended for cable routing, but not required (Fig. 4d and 4e). For these additional Lego parts, the colours do not matter as all parts are hidden inside the model in the end.

Second, Table 1 lists additional required electronic components. The number and specifications of consumables (e.g., wires, pins) is a minimum recommendation. The rightmost column of Table 1 refers to the figure number of the pictorial design and manufacturing process documentation as presented next.

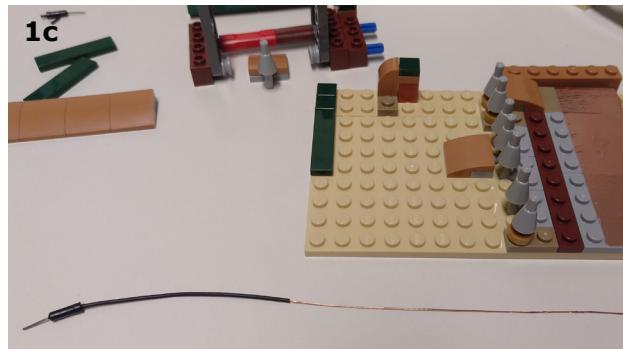
#	Description	Specifications	Fig.
1	copper tape	2.5 cm width x 50 cm length	1b
38	jumper wires (connected)	20 cm long each (terminated as male to female pins)	1c
1	wire (hooked-up stranded)	625 cm long (25 cm x 25 keys), max. outer diameter 0.8 mm ² , cross section 0.05 mm ²	2a
34	header pins	25 for keys, 9 to turn female to male for breadboard wiring	2e
1	Small breadboard	3,5 cm height x 4,7 cm width	5a
1	Arduino Mega	plus USB cable of 1 m length	5a
2	resistors	220 ohms	5b
1	MIDI connector	plus MIDI cable of 1 m length	5c

Table 1 Additional electronic components required

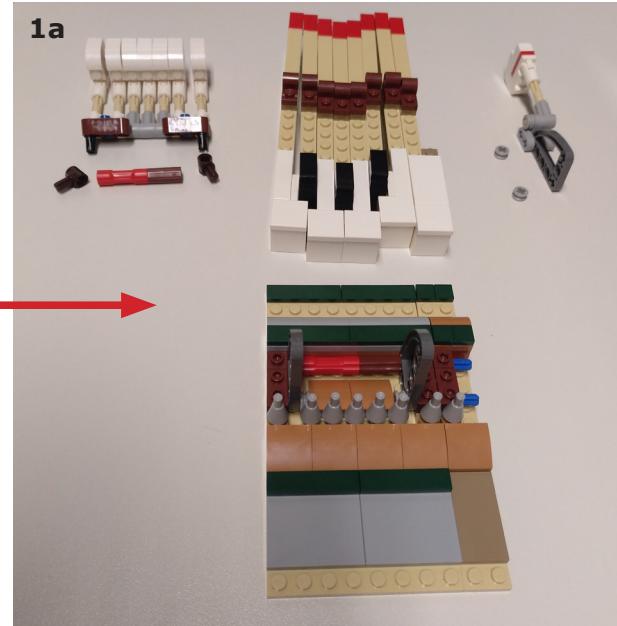




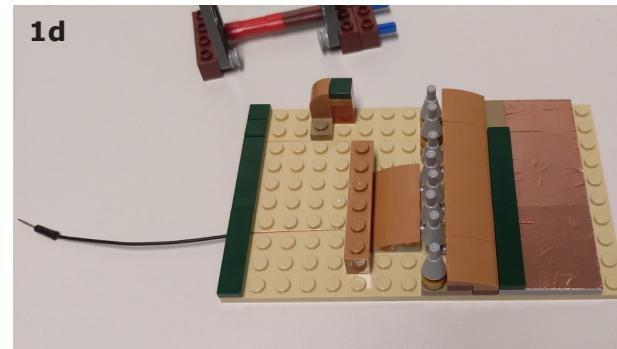
Step 1: Create the electric ground of a keyboard block
 General note for Step 1: Remove the whole keyboard block from the piano as described in the original instructions ([3] p.546). You have to do this only for the first time doing this step. For the following steps 1-3, separate the four keyboard blocks from each other and handle them separately one after each other to electrify all 25 keys. Start with the rightmost block.



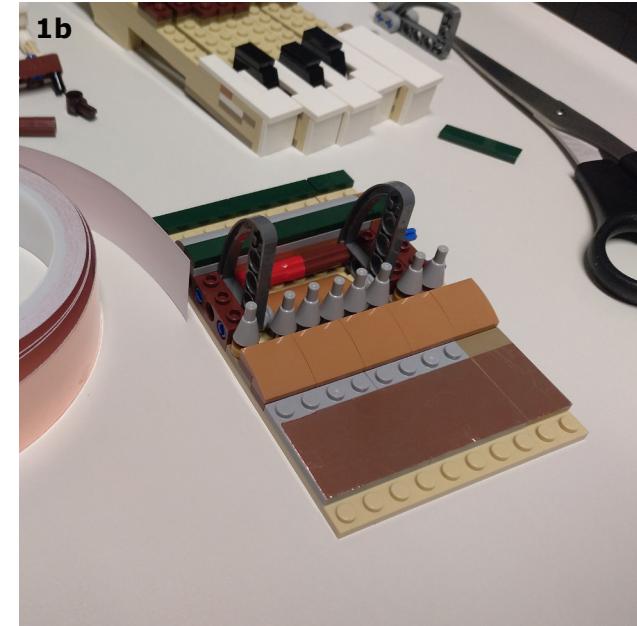
1c: Remove even more parts from the keyboard block, cut a jumper wire with a pin at the length of ~20 cm and strip half of it. If available use a black wire as this is the common colour for the ground.



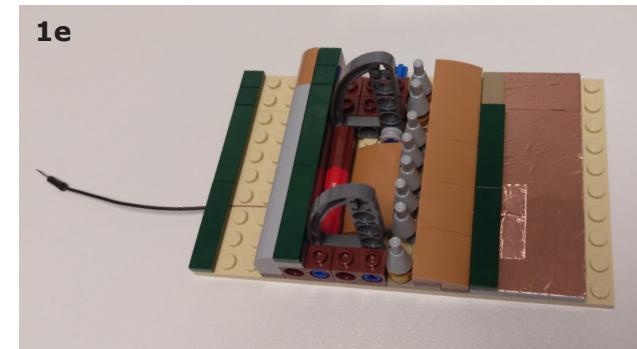
1a: Disassemble the hammers including their mounts and all keys from the keyboard block. Repeat from here for the other separate keyboard blocks after you have finished Step 1-3 with the first rightmost block.



1d: Place the stripped half of the wire between two rows of studs from the back of the keyboard block to the front and ensure that the wire touches the copper tape surface. Reassemble the bricks to fix the stripped wire.



1b: Take the copper tape and cut out a piece that fits on the tiles where the keys usually hammer on while playing. Remove the green tile and apply piece of copper. This will be our electric ground.

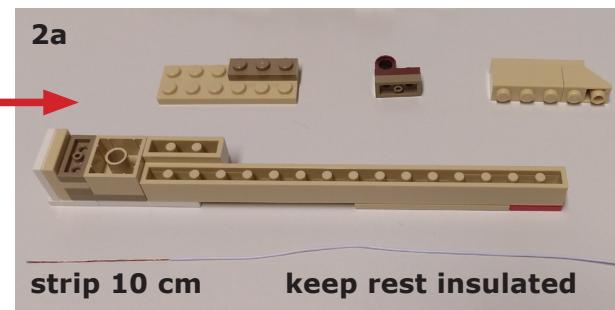


1e: Cut a small piece of copper tape to fix the stripped wire on the copper tape surface and reassemble the rest of the previously removed bricks.

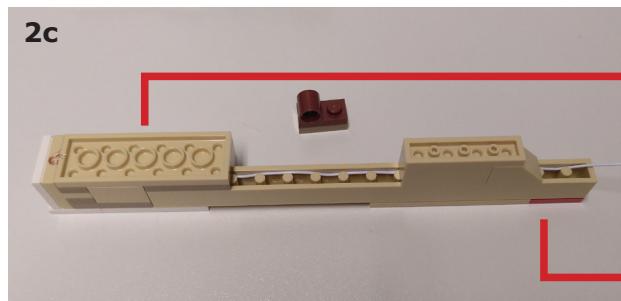


Step 2: Variant “wiring rightmost C key”

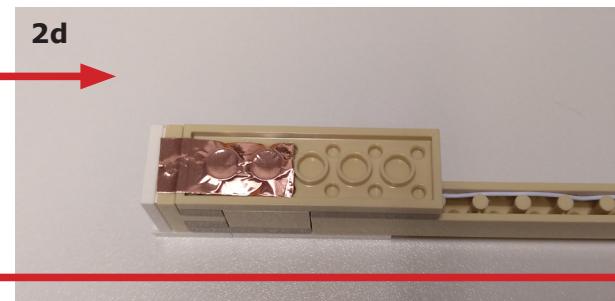
General note for Step 2: There are five types of keys in two colours: One type of black keys and four types of white keys (“C/F”, “D/G/A”, “E/B” and “rightmost C”). The wiring of the keys is similar for all types. We use the “rightmost C” to explain the wiring in detail and describe the differences to the other key types afterwards.



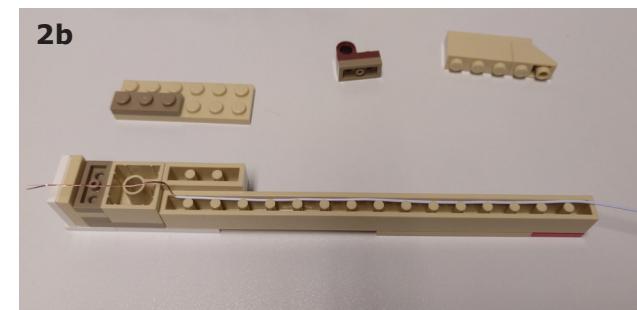
2a: Remove some small parts on the top and bottom side of the key, prepare a wire about ~25 cm long, strip the wire ~10 cm and turn the key upside down.



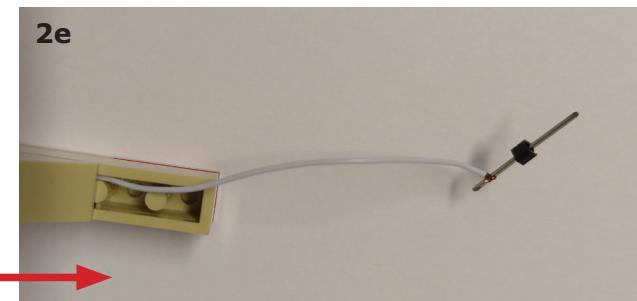
2c: Fix the stripped wire by reassembling the plates on the front, but keep a small piece visible. Reassemble the brick on the back of the key to fix the insulated wire.



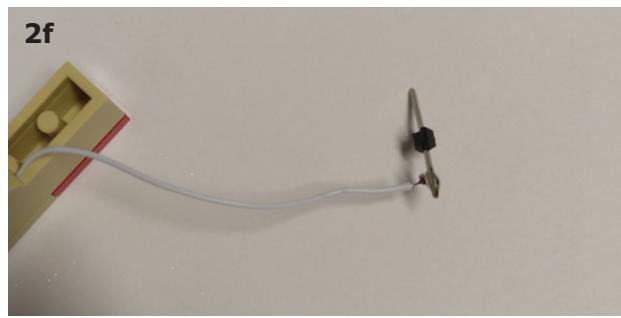
2d: Fix the visible stripped wire with copper tape. Be sure the copper fixes all strands and is smaller than the key width to prevent short circuits with adjacent keys.



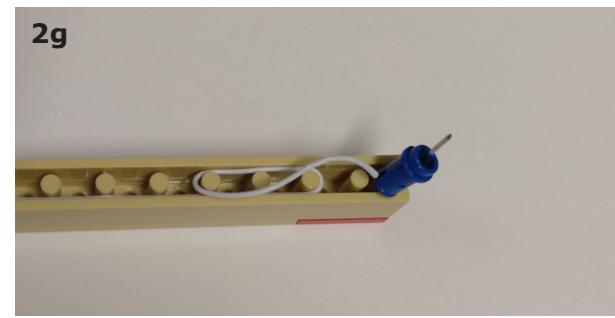
2b: Place the insulated part of the wire inside the long brick and keep the stripped part beyond the front of the key.



2e: Remove 1-2 cm of insulation from the wire end on the back of the key and wind this stripped end around one side of a header pin.



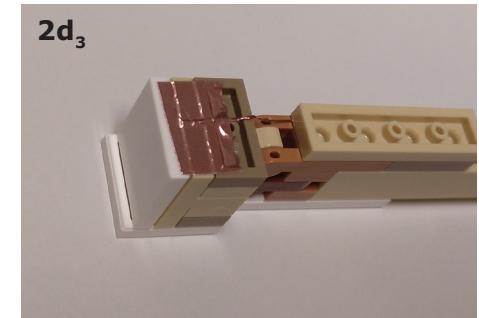
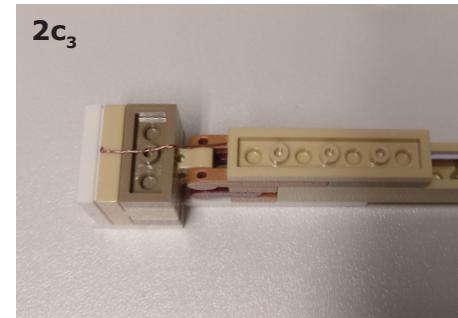
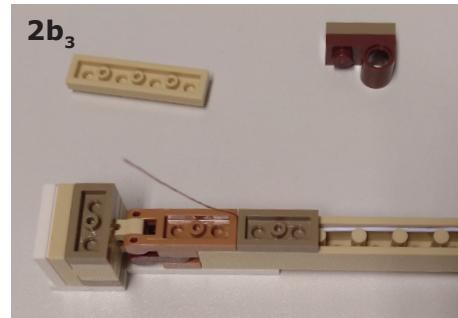
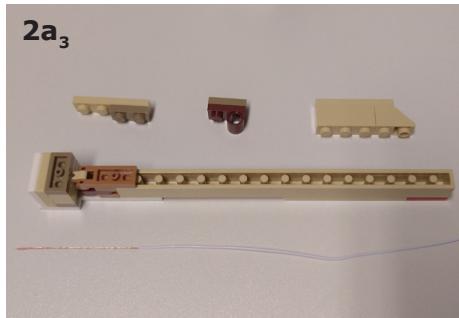
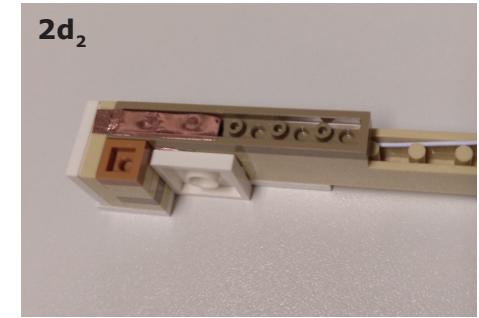
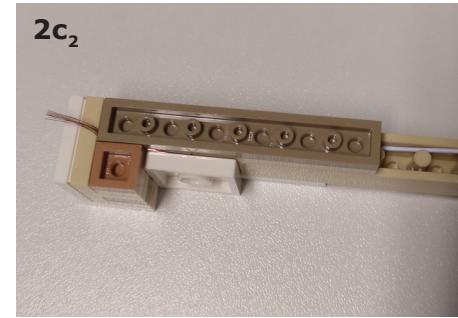
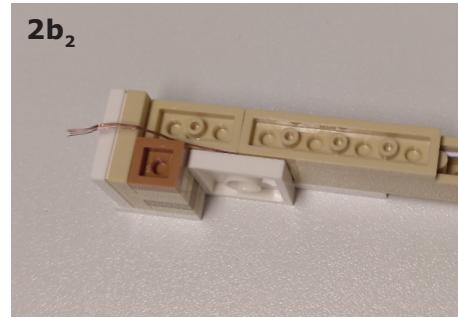
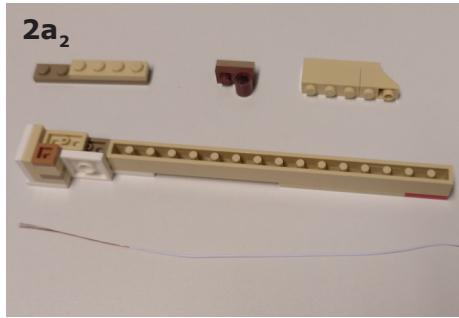
2f: Optionally, you can solder the wire on the header pin to fix it firmly, but it still works well without soldering.



2g: Use a LEGO Technic pin 1/2 to cover and fix the wired part of the header pin. Temporarily remove the brick again to stow overhanging wire inside the brick.



2h: To finish the wiring of this key, put the LEGO Technic pin 1/2 inside the last space of the brick's inside. Ensure that the unwired side of the header pin sticks out.



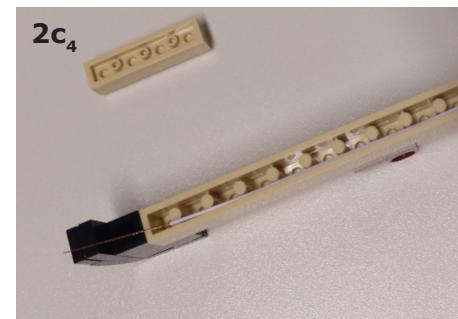
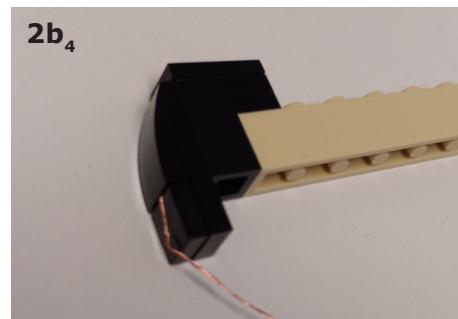
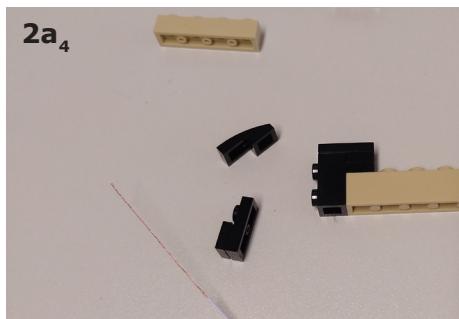
Step 2: Variant “wiring white keys”

General note: Follow 2a₂-d₂ to wire C/F and (mirrored) E/B key types, while 2a₃-d₃ show the wiring for D/G/A key types.

The wiring works similar to the “right-most C” with some variations for the steps 2a-d as all other white keys are constructed slightly different on their

front side having less space to lay and apply the stripped wire inside the bricks. Thus, the wiring of the stripped part and applying the copper tape has to be done

carefully to avoid overhanging parts which can create short circuits with adjacent keys. Steps 2e-h remain the same as described on the previous page.



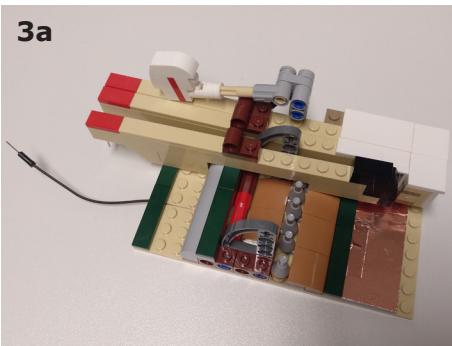
Step 2: Variant “wiring black keys”

2a₄: For the black keys, also remove some parts from the front of the key.

2b₄: Be sure that the stripped wire is fixed between the 1x1 black tile and the 2x1 black curved slope on the front.

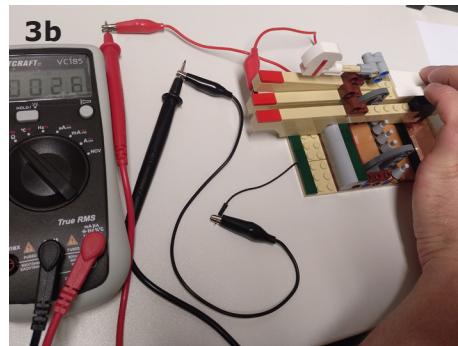
2c₄: When laying the wire through the brick's inside, be sure the stripped part goes around the key's front bottom.

2d₄: Avoid overhanging stripped wires and be sure that the applied copper tape is smaller than the width of the brick.

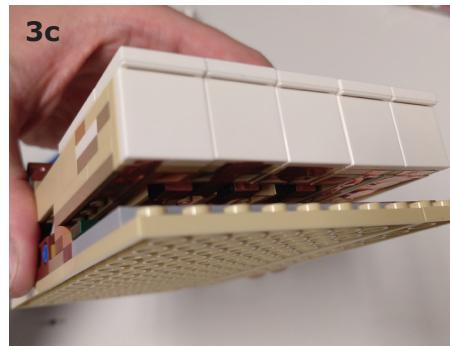


Step 3: Reassembling of wired keys

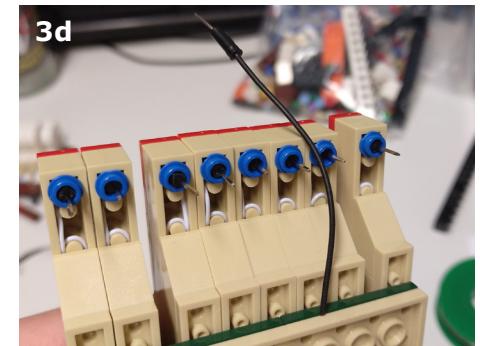
3a: Put each key one by one back on the keyboard block's base. Do not assemble the hammers yet, if you want to do the optional connectivity check.



3b: Optionally, but recommended, check the connectivity of each key to the ground separately to fix any connectivity issues as early as possible. Only when a key is pressed, the circuit of should be closed.



3c: After you have fully reassembled a keyboard block including the hammers, you should barely see the copper tape on each key's bottom side and the keyboard block's plate.

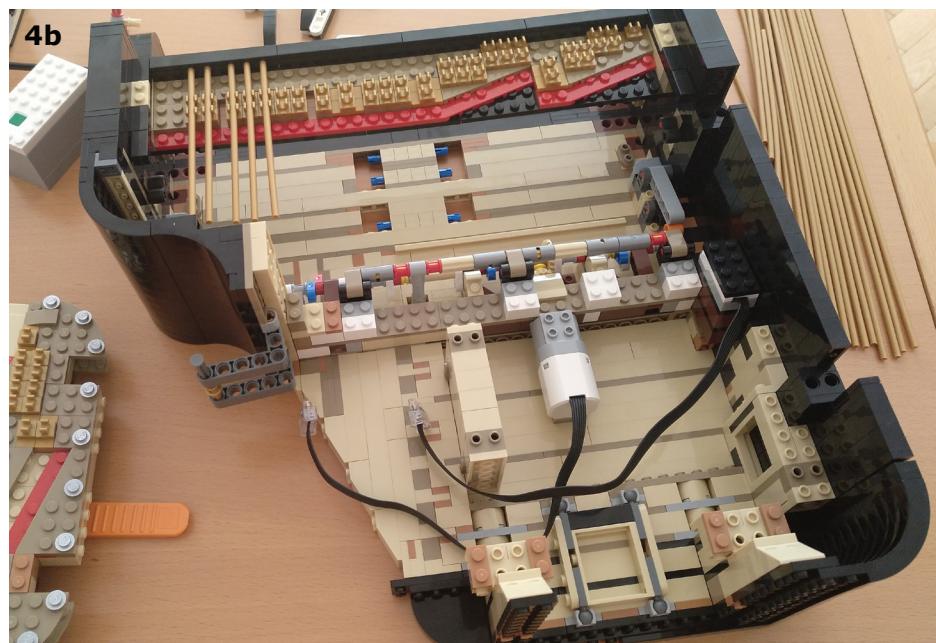


3d: On the back of the keyboard block, you should only see the (black) loose ground jumper wire and the fixed visible header pins. Repeat Step 1-3 for the remaining keyboard blocks.

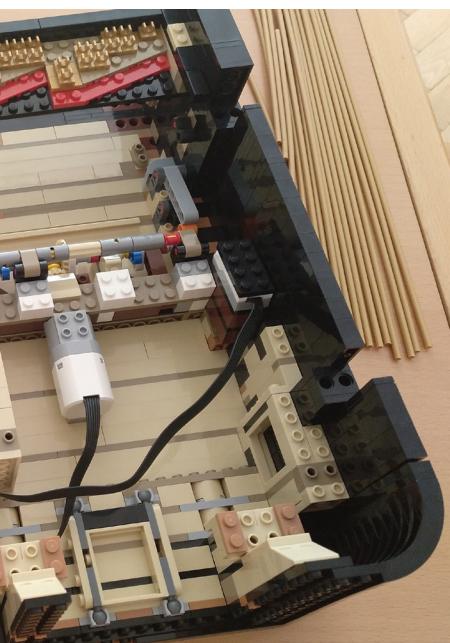


Step 4: Modify piano and wire keyboard

4a-c: After all four keyboard blocks are electrified by repeating the Steps



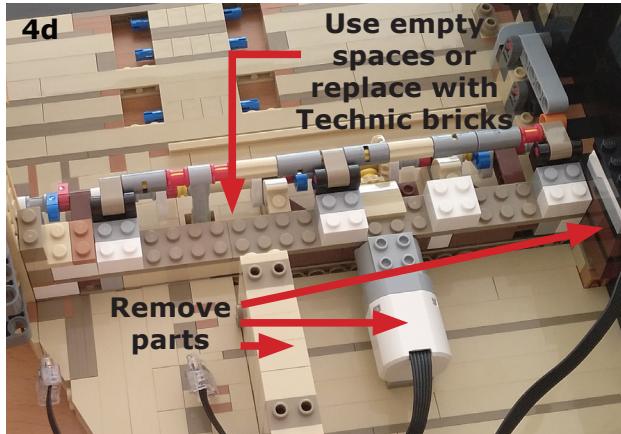
1-3, prepare and modify the interior of the piano for reassembling and wiring the keyboard. Disassemble most of the



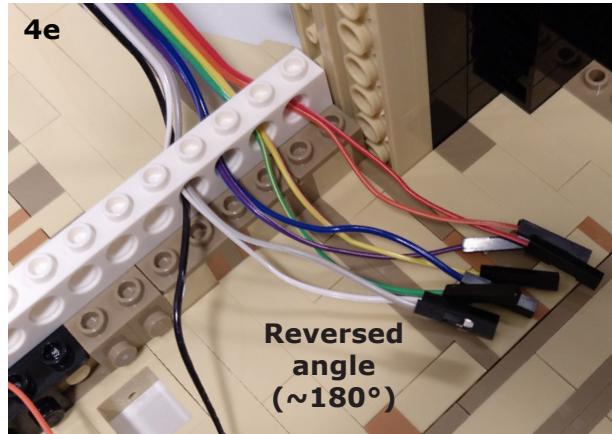
interior of your piano. Leave the pedal bar, but completely remove the existing electronic components and the self-play



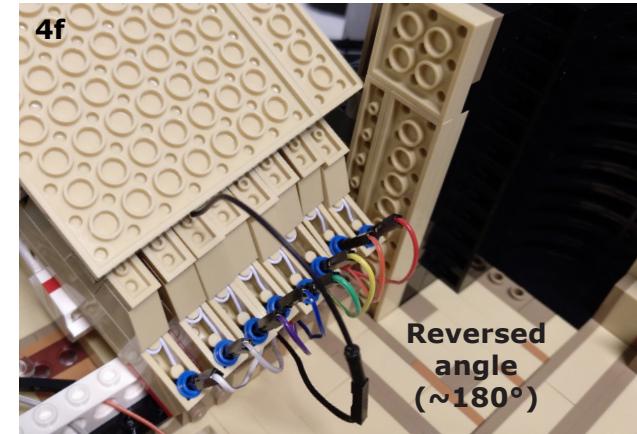
mechanism (steps 78-119 in the original instructions). Keep removed components aside as we will need some of them later.



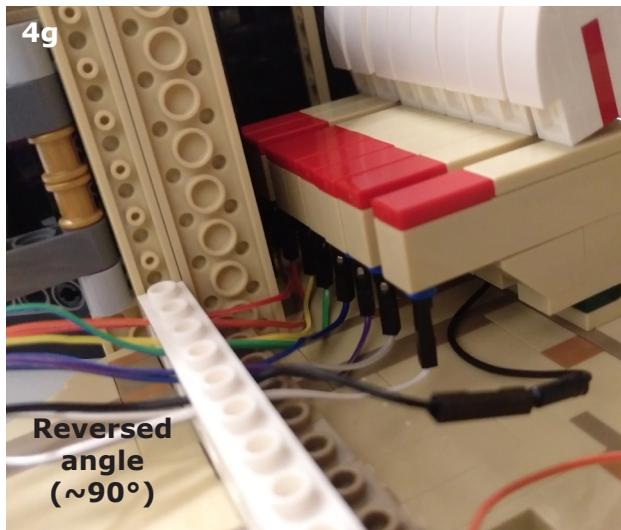
4d: Apply any kind of your own spare Lego Technic bricks of variable length on the same level where the self-play mechanism was earlier to better guide the 29 wires (25 keys, 4 grounds). If you do not have any spare Lego Technic bricks, use the empty spaces between the white 1x2 bricks to lay the wires through.



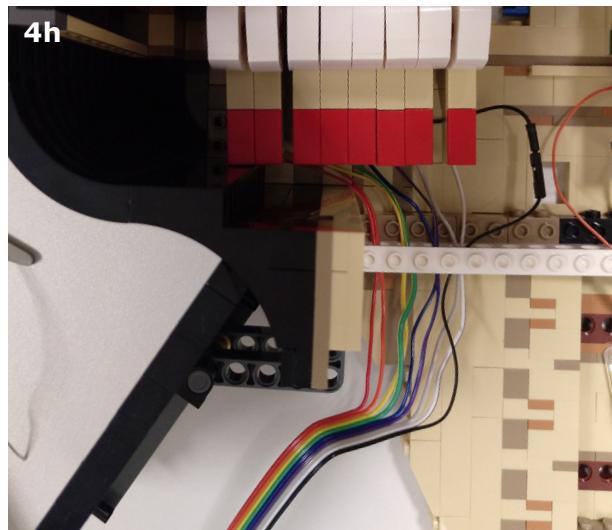
4e: Lay the 29 jumper wires through these holes. Ideally, use four sets of connected and coloured jumper wire connectors, one for each keyboard block, for a better handling. For the rightmost keyboard block lay two jumper wires through one hole as there is not much space in this area of the piano.



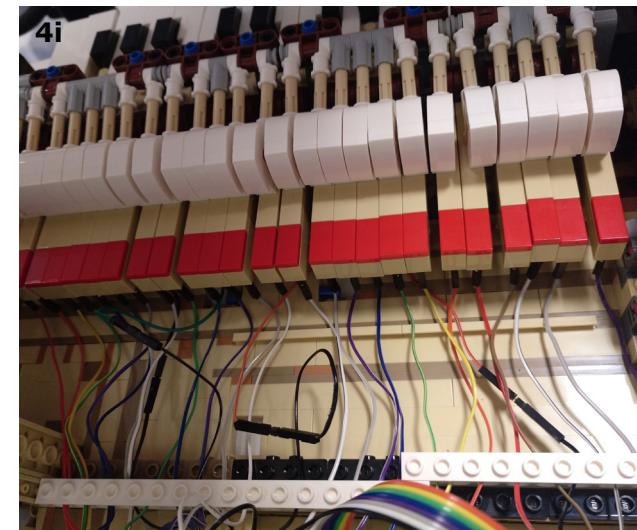
4f: Flip the keyboard block over and lay it on top of the cable guiding Technic brick to connect the jumper wires to the header pins of the keys. Use the different colours of the jumper wires for systematic wiring. Finally, wire the ground and ideally use a black jumper wire to keep a consistent colour-coding.



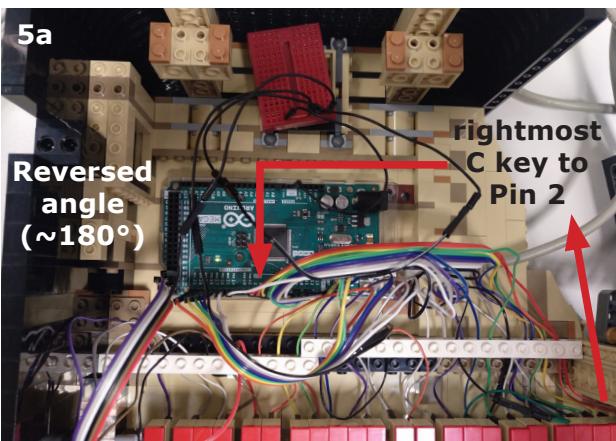
4g: When the wiring of the keyboard block is finished, turn around the block and readjust the connected wires if necessary to avoid crossed-over wires.



4h: Keep the jumper wires of a keyboard block connected but allow loose ends for room to move when the key is pressed. Check if each key moves freely.

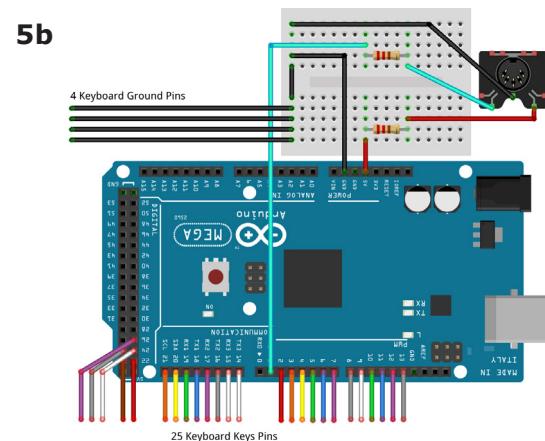


4i: When all keyboard blocks are wired, push and place the keyboard to its original position. Sort and arrange the jumper wires straight but not too tight.

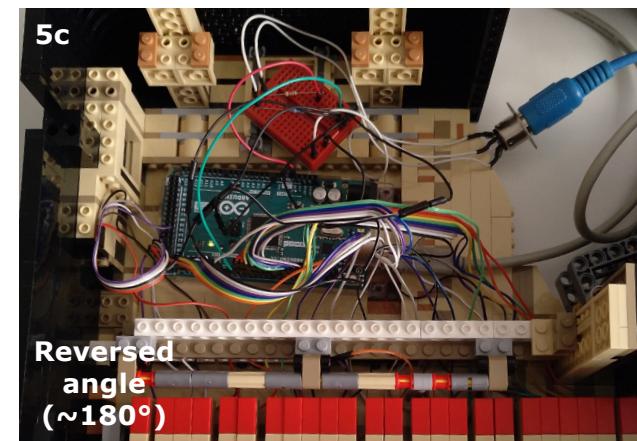


Step 5: Connect Arduino and reassemble piano

5a: Put the Arduino Mega and the small breadboard in the emptied space of the piano and connect the 25 key jumper cables from right to left to the input pins from 2 to 26. Note: to electrify the pedal, which is optional, you *should* do Step 6 first and then continue with Step 5.



5b: Assemble all other electronic components according to the circuit diagram on the small breadboard: 2 resistors, the MIDI connector and jumper wires for the pins 5V, GND and 1 of the Arduino. Depending on the type of the MIDI connector, it might be necessary to solder the wires on the 3 pins of the MIDI connector.



5c: Reassemble the pedal bar and add spare bricks. Use a USB cable to connect the Arduino to your computer and a MIDI cable to connect the MIDI connector to your sound interface. Note: computers usually do not have a standard MIDI port. You will need an extra external sound interface or a MIDI-to-USB-connector.

```

// Playable Lego Grand Piano | Arduino 1.8.1
File Edit Sketch Tools Help
Playable_Lego_Grand_Piano
[anonymised comments]

// state of 25 keys
int keyState[25] = {0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
// last state of the 25 keys for state change detection
int keyprevState[25] = {0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0};
// MIDI pitch 25 tones (2 octaves from C to C#)
// 440 Hz is represented in MIDI terms by the integer 69, which is a
int noteValue[25] = {69,71,70,69,68,67,66,65,64,63,62,61,60,59,58,57,56,55,54,53,52,51,50,49,48};

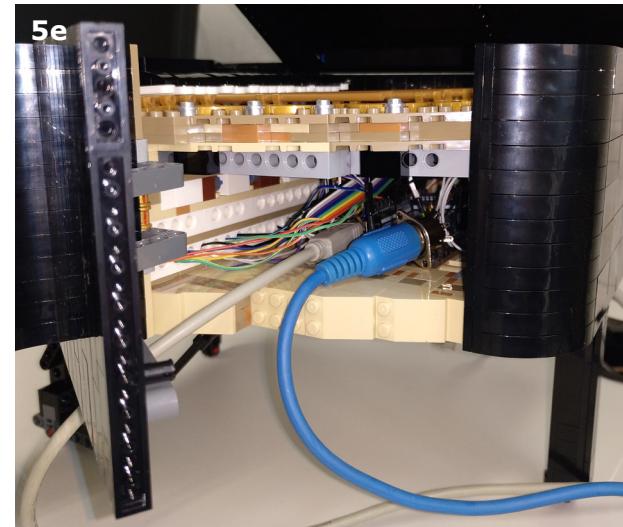
void setup() {
    for (int i=pin = 2; i<pin < 27; i+=pin++) {
        pinMode(i, INPUT_PULLUP);
    }
    // Set Serial Monitor baud rate (for debugging):
    //Serial.begin(9600);
    // Set MIDI baud rate:
    Serial.begin(31250);
}

// setup() end

Data sampling
Sketch uses 2836 bytes (1%) of program storage space. Maximum is 283982 bytes.
Global variables use 334 bytes (4%) of dynamic memory, leaving 7658 bytes for local variables. Free RAM: 7658 bytes.

```

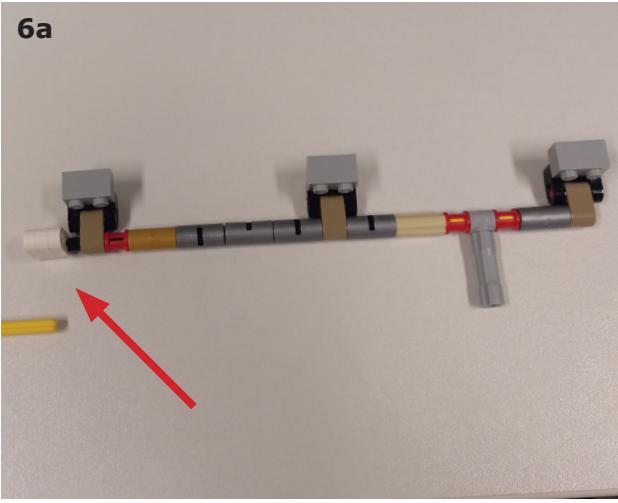
5d: Use (and eventually install) the Arduino IDE [4], download the provided open-source sketch [5] and upload it to the Arduino.



5e: Reassemble the previously removed parts of the piano (e.g., strings, lids). You can remove one brick to make space for the cables when the side lid is closed.

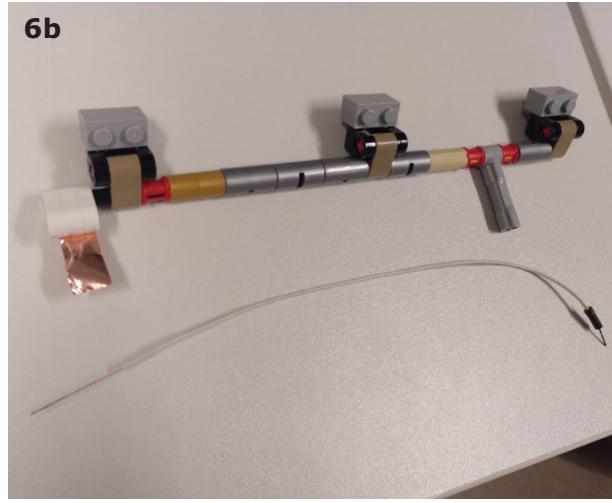


5f: The Lego Grand Piano is now electrified and (really) musically playable using a MIDI compatible sound device or software.

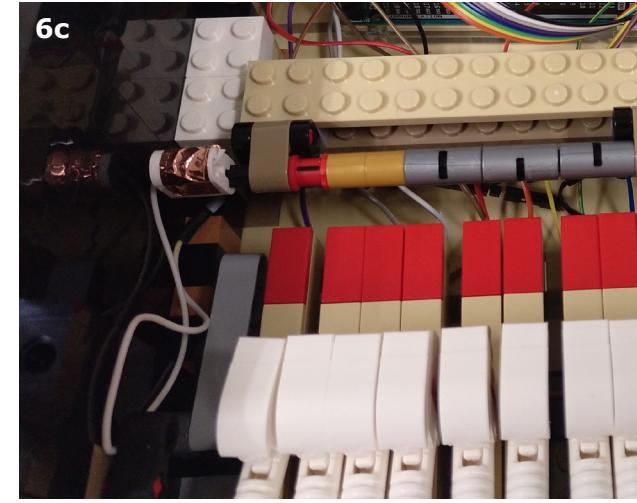


Step 6: Wiring the pedal (optional, see Step 5)

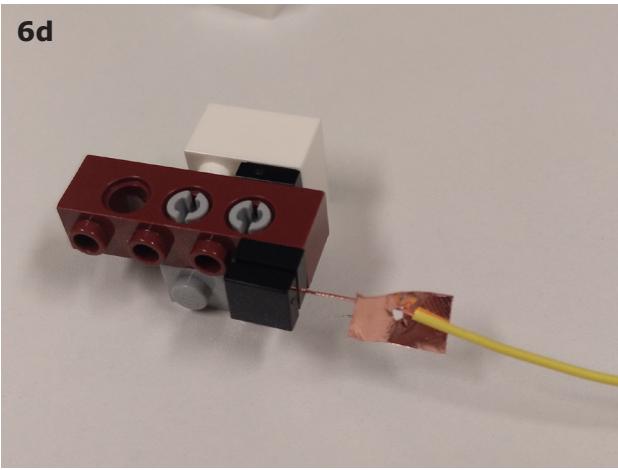
6a: Modify the pedal bar from the inside of the piano. On its left, replace the yellow axle with a slightly longer black one and add 3 white Technic beams 1x2.



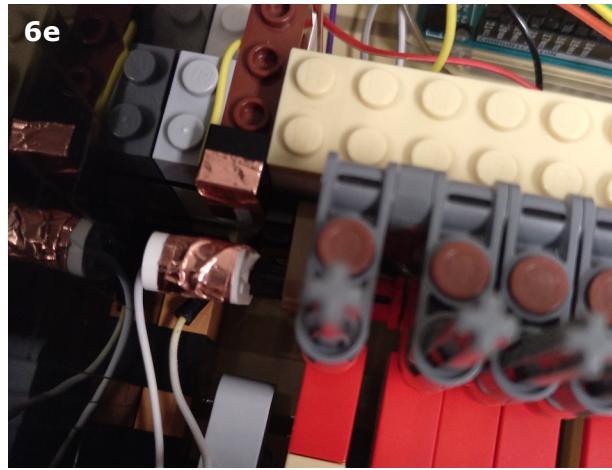
6b: Take a jumper wire slightly longer than the pedal bar and strip the end. Add a piece of copper tape to the previously extended end of the pedal bar to fix the stripped part of the wire.



6c: Reassemble the pedal bar and add some spare bricks, e.g., white and tan ones you removed earlier, near the copper taped end of the pedal bar. Thread the jumper wire to the Arduino and plug it into input 27.



6d: Use another stripped jumper wire and some of the remaining spare bricks removed earlier to build the ground for the pedal switch. There is no need to make an exact copy of the illustration, but ensure that the height is similar and the stripped wire is firmly copper taped.



6e: Place the assembled part besides the pedal bar. Check if the coppered areas connect, when the piano pedal is pressed. If not, use spare bricks or remove bricks to adjust the height. Plug in the jumper wire to the breadboard where the other grounds are plugged in.



6f: The right movable pedal of the piano is now electrified and working. It can be pressed to lift the dampers as originally intended, but in addition outputs a MIDI signal.

Acknowledgements

Thanks to Judith Ammann for her assistance with the creation of this building instruction. Thanks to Joseph Krpelan for his concert photographs used on page 1 and 10. This work was funded in part by the Austrian Science Fund (FWF) [10.55776/WKP126].

Related Scientific Publication

O. Hödl, "An electronic engineering approach for turning a Lego brick piano into a musical instrument," in IEEE Access, 2024, doi: 10.1109/ACCESS.2024.3386361

References

- [1] <https://www.lego.com/en-gb/product/grand-piano-21323>
- [2] <https://www.bricklink.com/v2/catalog/catalogitem.page?P=4274&name=Technic,%20Pin%201/2%20without%20Friction%20Ridges&category=%5BTechnic,%20Pin%5D#T=C>
- [3] <https://www.lego.com/en-at/service/buildinginstructions/21323>
- [4] <https://www.arduino.cc/en/software>
- [5] <https://www.drhoedl.com/permalink/theplayel>

