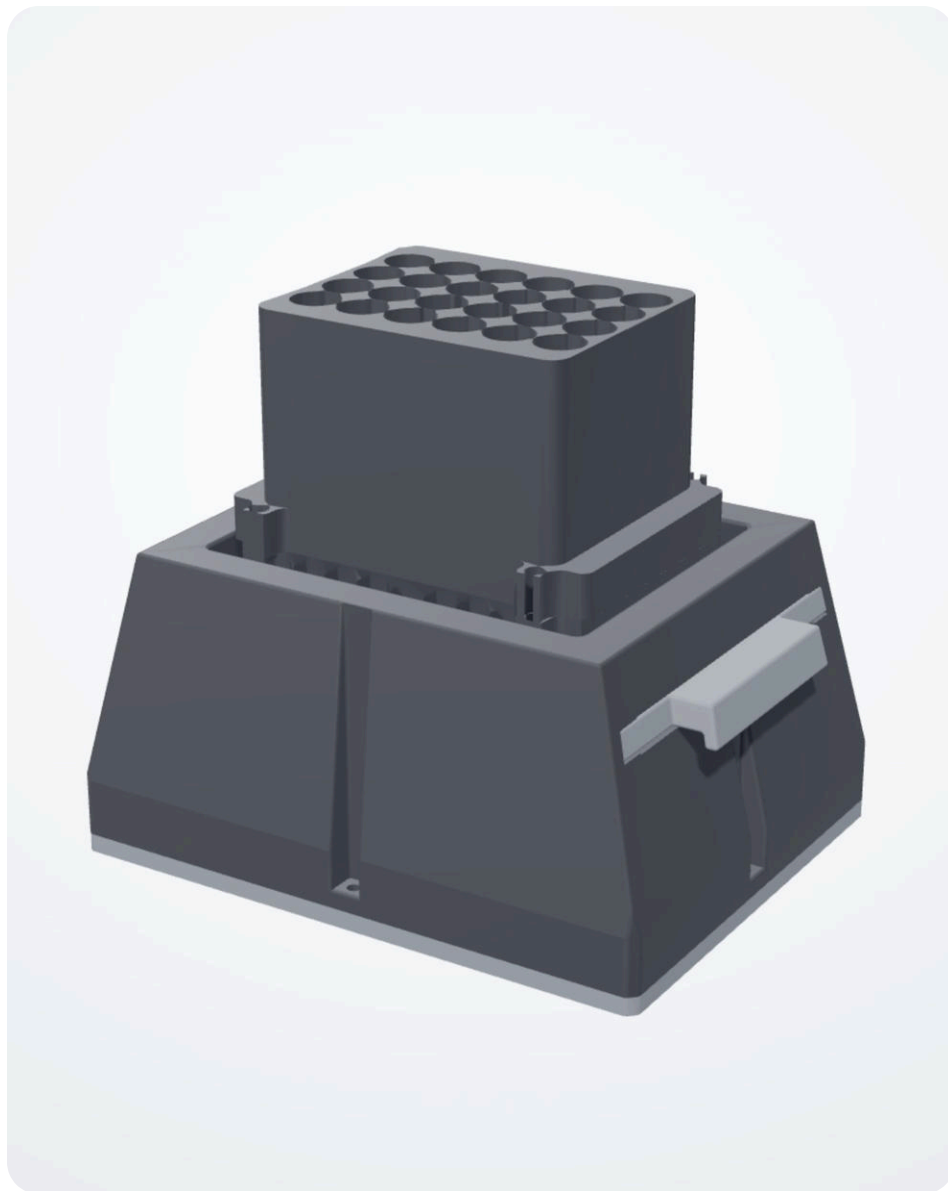


LPA

Light plate apparatus · Assembly guide

Lights 24 culture tubes in green and red at three set intensities, from one Arduino and three MOSFETs: six light conditions, four tubes each.



⚠ SAFETY

- ◆ The soldering iron runs at 320 °C. Keep it in its stand and never touch the tip.
- ◆ Solder in a ventilated room or under a fume extractor. Do not breathe the smoke.
- ◆ Wear eye protection when you solder or clip leads.
- ◆ Switch off the bench supply and unplug the Arduino before you change any wiring.
- ◆ Do not look straight into the LEDs at full brightness.
- ◆ Heat-set inserts stay hot after you press them in. Let them cool before you touch them.

Tools and supplies

- 3D printer (Bambu Lab X1 Carbon), Bambu Studio
- Soldering iron and solder
- Wire strippers
- Screwdriver (the only tool the assembly needs)
- Light meter
- Bench power supply, 5 V
- Black electrical tape, masking tape, a pen
- Computer with the Arduino IDE

Files

Print files Download the STL files from the Design Files section of our wiki's LPA page.

Run sketch LPA.ino, printed in full in Stage 6.

Parts checklist from the wiki's materials list (LPA page, 5.1)

QTY	PART	DETAILS
LIGHT		
☐	12 Green LEDs	5 V, built-in resistor. Buy 20 to pick 12 from
☐	12 Red LEDs	5 V, built-in resistor. Buy 20 to pick 12 from
☐	24 LED sockets	PCV-220
ELECTRONICS		
☐	3 MOSFETs	IRLZ44N, logic-level
☐	1 Microcontroller	Arduino Uno R4 WiFi
☐	1 Perf board	160 × 100 mm
☐	12 Jumper wires	20 AWG, 10 cm: female–male and male–male
HARDWARE		
☐	4 Screws, M6 × 45 mm	stainless: tube holder and LED holder to the sliders
☐	4 Screws, #10-32 × 1/2 in	stainless: base plate to the housing, from underneath
☐	4 Screws, M3 × 10 mm	stainless: perf board to the base plate's stands
☐	4 Heat-set inserts, M3	brass: in the tops of the stands
☐	Filament	Bambu PLA Matte, black, about 933 g

STAGE 1

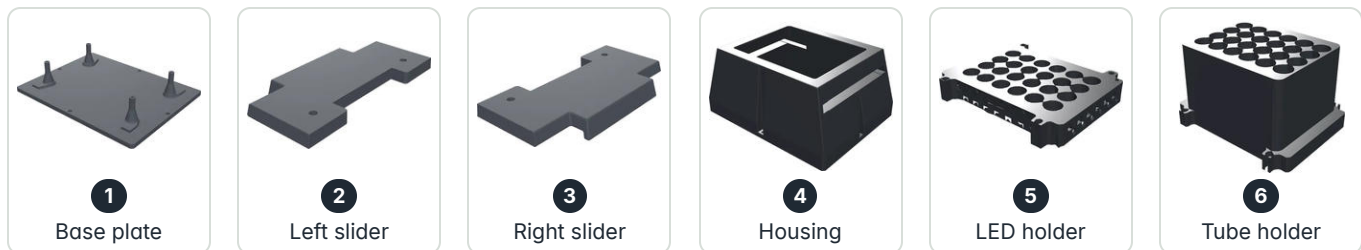
Print the parts

YOU NEED

- 3D printer with black PLA Matte, about 933 g
- The 6 STL files

Printer	Bambu Lab X1 Carbon, 0.4 mm nozzle, textured PEI plate	Profile	0.20 mm Standard @BBL X1C: layer height 0.2 mm, first layer 0.2 mm
Infill	15 %, gyroid	Supports	Normal (auto), 30° threshold
Filament	PLA Matte, black, for every part	Tube holder	4 wall loops, so no light crosses between wells

- 1 Download the STL files from the Design Files section of our wiki's LPA page.
Six parts are printed. The seventh file, the perf board, is only for checking the fit.
- 2 Open them in Bambu Studio, with the settings in the table.
- 3 Set every part's filament to black PLA Matte.
- 4 Set the tube holder to 4 wall loops.
- 5 Slice each plate and print it.
- 6 Remove the supports.



✓ CHECK

1. You have all six printed parts.
2. The tube holder is black, printed with 4 wall loops.

YOU NEED

- All the green and red LEDs
- 24 PCV-220 sockets
- The LED holder **5**
- A light meter
- Black electrical tape
- Bench power supply, set to 5 V
- Masking tape and a pen

Matching makes the four LEDs of each column even. The run sketch then sets each tier's brightness (Stage 6).

- 1** Tape over the light meter's sensor with black electrical tape, leaving only a 10 mm (1 cm) circle open.
- 2** Push each green LED into a PCV-220 socket, and the socket into the LED holder.
- 3** Connect all the green LEDs to the bench supply at a constant 5 V.
- 4** Put the sensor's open circle over the hole of one lit LED.
- 5** Slide the sensor slowly until the reading is at its highest.
- 6** Write that lux value on a piece of masking tape and stick it on the LED.
- 7** Repeat steps 4 to 6 for each green LED.
- 8** Switch off the supply and take out the green LEDs. Repeat steps 2 to 7 with the red LEDs.
- 9** Sort each colour into groups of four with the closest readings.
- 10** Make three tiers from them: low, medium and high.
Low is the lowest green group and the lowest red group, and so on up.
- 11** Set the spare LEDs aside.

CHECK

1. Each group of four reads close together. In our build, the four LEDs of a group were within 0.4–1.8 % of each other.
2. Every LED in the array is labelled with its reading.

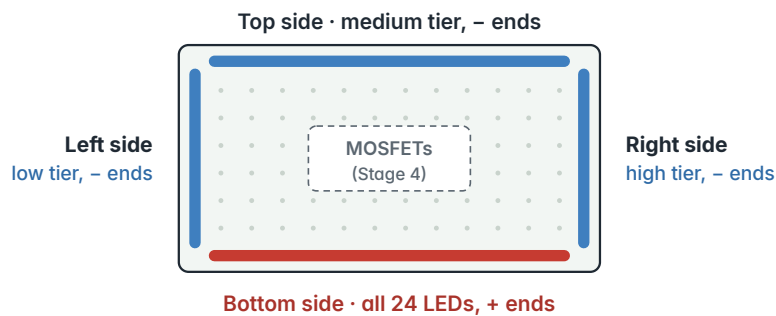
STAGE 3

Solder the LEDs to the perf board

YOU NEED

- The perf board
- The matched LEDs, in their three tiers
- Soldering iron and solder
- Bench power supply, 5 V

- 1 Heat the soldering iron to 320 °C.
- 2 Solder the negative (–) ends of the low tier, green and red, to the left side of the perf board.
- 3 Solder the negative ends of the medium tier to the top side.
- 4 Solder the negative ends of the high tier to the right side.
- 5 Solder the positive (+) ends of all the LEDs to the bottom side.



Where each tier's ends go.

✓ CHECK · TEST 1

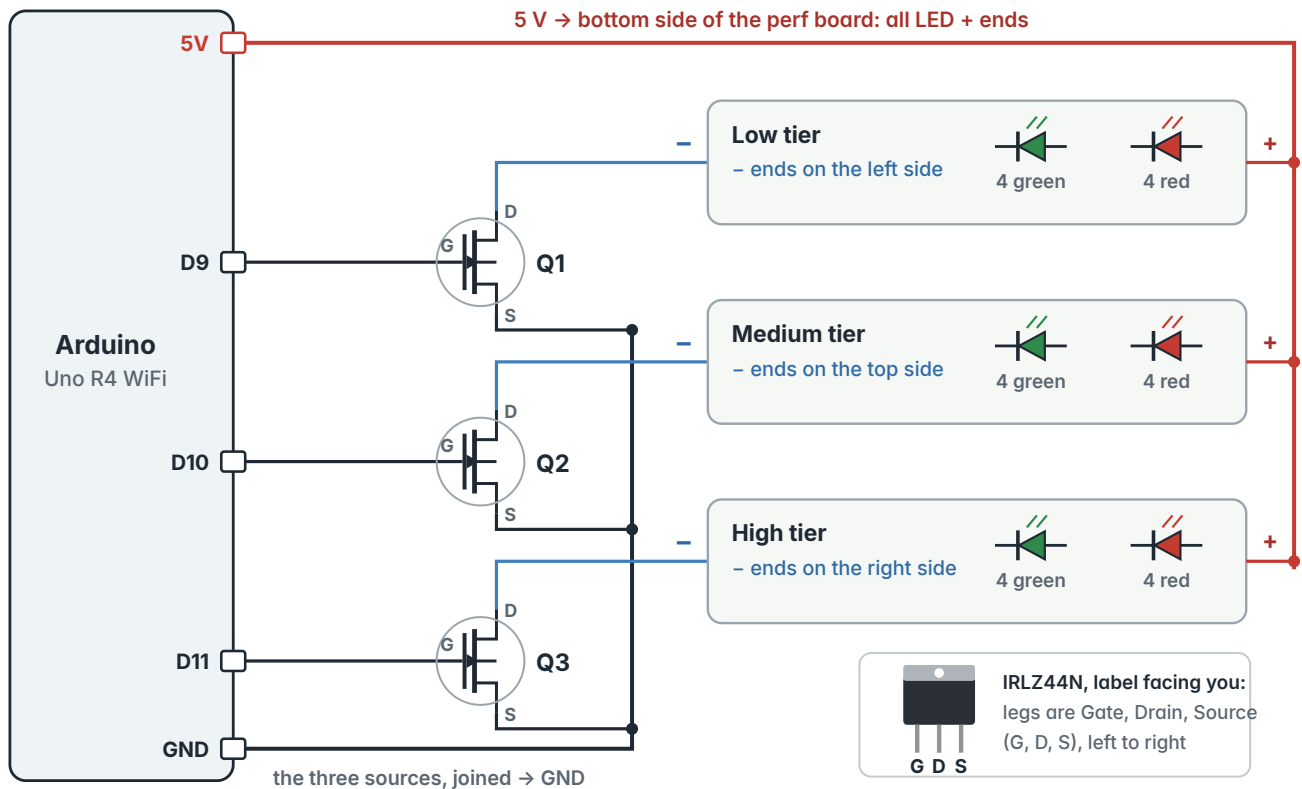
With the bench supply at 5 V, power one tier at a time: + to the bottom side, – to that tier's side.

1. Low tier (left side): all 8 of its LEDs light.
2. Medium tier (top side): all 8 light.
3. High tier (right side): all 8 light.

If it fails: Resolder both ends of any LED that stays dark.

YOU NEED

- 3 IRLZ44N MOSFETs
- Jumper wires: female–male and male–male
- Arduino Uno R4 WiFi
- Computer with the Arduino IDE
- Soldering iron and solder



What the steps below connect. Each tier is a green column and a red column of four, switched by its own MOSFET.

- Put the 3 MOSFETs into the centre of the perf board, from its bottom face.
- Solder their legs.
Do not let solder join two legs.
- Plug a female–male jumper wire onto each MOSFET leg.
- Connect each MOSFET's drain and gate as in the table below.

MOSFET	DRAIN TO	GATE TO	TIER
Q1	left side of the board	Arduino D9	low
Q2	top side of the board	Arduino D10	medium
Q3	right side of the board	Arduino D11	high

- Join the three sources together, then connect them to the Arduino's GND.
- Connect the bottom side of the board (all LED + ends) to the Arduino's 5 V pin with a male–male jumper wire.

✓ CHECK · TEST 2

1. Upload the test sketch below. It lights one tier at a time at full brightness, then dims and brightens it.
2. While D9 is on, only the low tier's green and red LEDs light.
3. Then only the medium tier (D10), then only the high tier (D11).
4. Each ramp from 0 to 255 dims and brightens smoothly.

If it fails: If other LEDs light, look for a bridged solder joint or a swapped gate wire.

```
// LPA Test 2: light one tier at a time, then ramp it
const int PINS[] = {9, 10, 11};

void setup() {
  for (int i = 0; i < 3; i++) pinMode(PINS[i], OUTPUT);
}

void loop() {
  for (int i = 0; i < 3; i++) {
    for (int j = 0; j < 3; j++) analogWrite(PINS[j], 0); // all tiers off
    analogWrite(PINS[i], 255); // this tier full
    delay(3000);
    for (int v = 0; v <= 255; v++) { analogWrite(PINS[i], v); delay(10); } // ramp up
    for (int v = 255; v >= 0; v--) { analogWrite(PINS[i], v); delay(10); } // ramp down
  }
}
```

The Test 2 sketch.

YOU NEED

- The printed parts
- The wired perf board and LED holder
- 4 M3 heat-set inserts
- 4 × M3 × 10 mm screws
- 4 × M6 × 45 mm screws
- 4 × #10-32 × 1/2 in screws
- Soldering iron
- A screwdriver

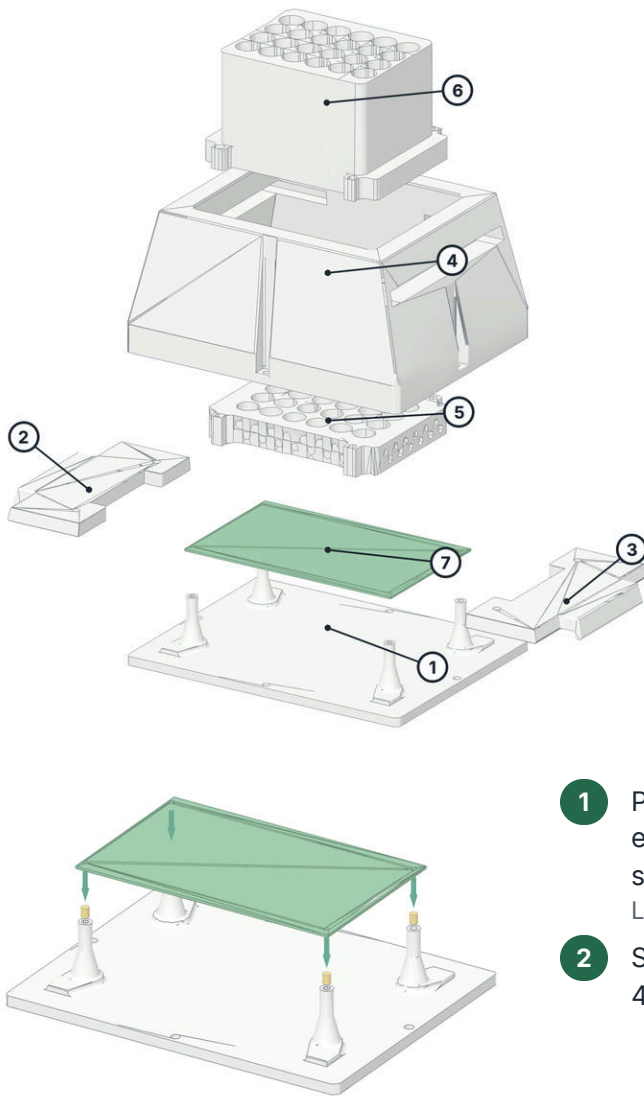
The parts, numbered as on the wiki (LPA page, 4.1). Green in the pictures marks what each step adds.

PRINTED

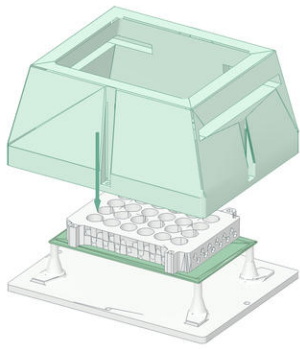
- ① Base plate
- ② Left slider
- ③ Right slider
- ④ Housing
- ⑤ LED holder
- ⑥ Tube holder

BOUGHT

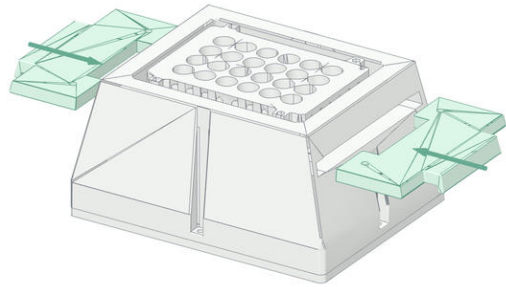
- ⑦ Perf board



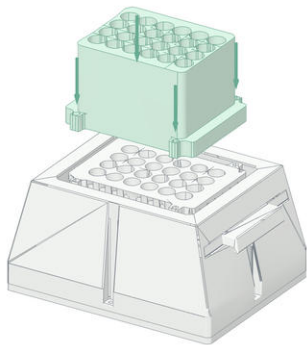
- ① Press an M3 heat-set insert into the hole at the top of each of the base plate's ① four stands, with the hot soldering iron, until it sits flush.
Let the inserts cool.
- ② Screw the perf board's ⑦ corners onto the four stands:
4 × M3 × 10 mm screws.



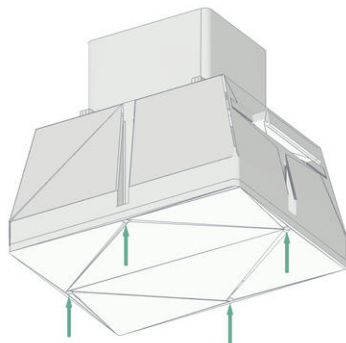
- 3 Lower the housing 4 over the perf board and the LED holder 5 wired to it.



- 4 Lift the LED holder up inside the housing.
- 5 Slide the left and right sliders 2 3 through the slots in the housing's sides until they stop. Rest the LED holder on them.



- 6 Place the tube holder 6 on top of the LED holder.
- 7 Screw the tube holder and the LED holder to the sliders: 4 × M6 × 45 mm screws, through the tube holder's corner holes.



- 8 Turn the LPA over. Screw the base plate to the housing from underneath: 4 × #10-32 × 1/2 in screws, through the holes in the middle of each edge.

✓ CHECK

1. Do Test 2 again (Stage 4).

If it fails: Look for a bridged solder joint or a swapped gate wire, as in Test 2.

 YOU NEED

- The assembled LPA
- A computer with the Arduino IDE and LPA.ino

- 1 Open LPA.ino in the Arduino IDE.
- 2 Upload it to the Arduino Uno R4 WiFi.

```
const int PIN_LIGHT1 = 9;
const int PIN_LIGHT2 = 10;
const int PIN_LIGHT3 = 11;
int x=0;
void setup() {
  pinMode(PIN_LIGHT1, OUTPUT);
  pinMode(PIN_LIGHT2, OUTPUT);
  pinMode(PIN_LIGHT3, OUTPUT);
}

void loop() {
  analogWrite(PIN_LIGHT1, 5); // ~2% duty cycle
  analogWrite(PIN_LIGHT2, 31); // ~12% duty cycle
  analogWrite(PIN_LIGHT3, 255); // 100% duty cycle

}
```

LPA.ino, the team's run sketch.

PIN	TIER	ANALOGWRITE	DUTY CYCLE
D9	low	5	5/255, about 2 %
D10	medium	31	31/255, about 12 %
D11	high	255	255/255, 100 %

 CHECK

1. All 24 LEDs light: the low tier dimmest, the high tier brightest.
2. The light stays the same for the whole run: the sketch sets it once and never changes it.