

TRONITION

Build a Car With Your Kid: the bench pack

Print these pages and keep them on the table while you build.

Version 2.0.1 · Bench pack (US Letter) · built 2026-10-01 · © 2026 Troniction. All rights reserved.

CHAPTER 1 • Before you decide

TABLE 1.1 The two Bluetooth modules. Everything else in the car is the same

	HM-10	HC-06
Phones that can drive the car	iPhone (with the free Bluefy browser) and Android (with Chrome)	Android only. An iPhone can't connect to it at all
What you drive it with	The Troniction remote, a web page	A free Android app, Serial Bluetooth Terminal
How this book checked it	The program and its wiring are tested on a computer, and the module's behavior is from its datasheet. Not yet built into a car	The module drove the original 2021 car for years. Its new wiring in this book is tested on a computer

CHAPTER 3 • The four boxes

□ TALK ABOUT IT

“Which box decides what to do? Which one does the pushing?”

PARENT: LISTEN FOR:

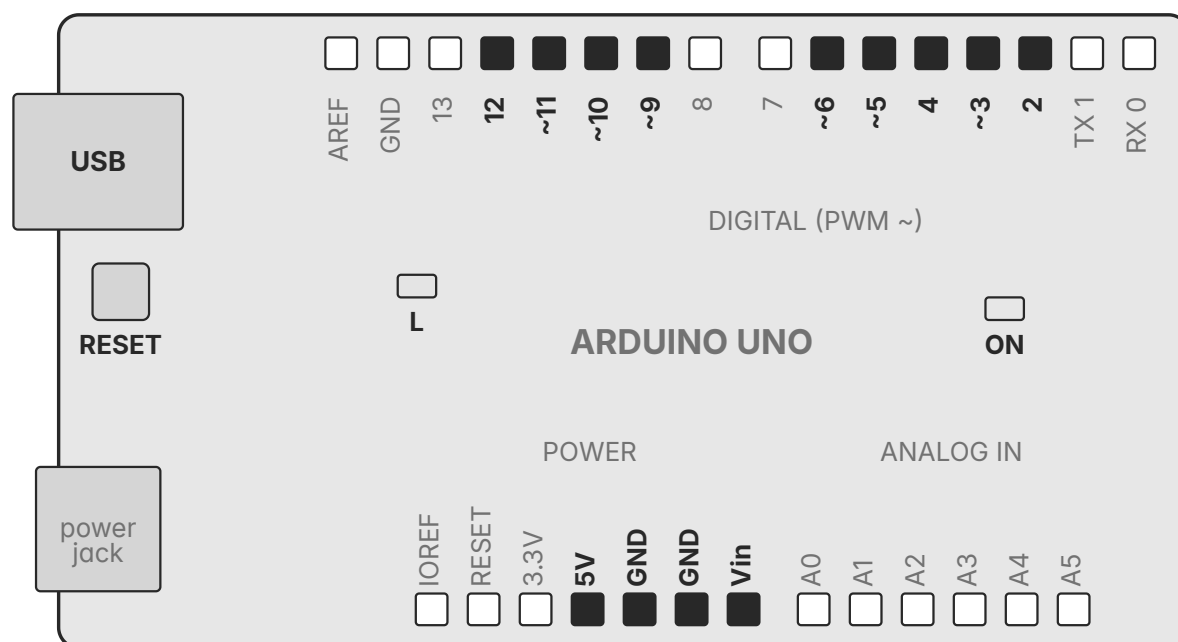
the board decides; the motor driver pushes, and the motors turn. Naming any box is a good start.

CHAPTER 4 • Unbox and find

TABLE 4.1 The parts. Prices and links are at troniction.com/go/car-parts

PART	HOW MANY	WHAT IT'S FOR
Board: Arduino Uno R3 (a clone is fine) and its USB cable	1	Runs the sketch; decides what the car does
Motor driver: L298N module, the screw-terminal kind	1	Takes battery power and pushes it into the motors
4WD chassis kit: plates, four wheels, four TT gear motors with wires already attached	1	The car's body and its wheels
Bluetooth module: HM-10 (DSD TECH) or HC-06 (Chapter 1 helps you choose)	1	Catches the letters from the phone
Battery holder for two 18650 cells, with an on/off switch and two wire leads	1	Holds the cells; the switch turns the power on and off
18650 rechargeable cells, button top	2	The car's power
18650 charger	1	Charges the cells

PART	HOW MANY	WHAT IT'S FOR
Passive buzzer module (a small board with a buzzer and three pins)	1	The horn, the reversing beep and the tune. Passive, not active: an active one only beeps
Mini breadboard, 170 holes	1	Joins the Bluetooth module's wires, without soldering
Resistors: one 1 k Ω and one 2 k Ω (2.2 k Ω also works)	1 each	Protect the Bluetooth module's listening pin
Jumper wires: male-to-female (at least 15) and male-to-male (at least 6)	21 or more	Every connection that isn't a screw terminal
Small Phillips screwdriver	1	The screw terminals and the chassis



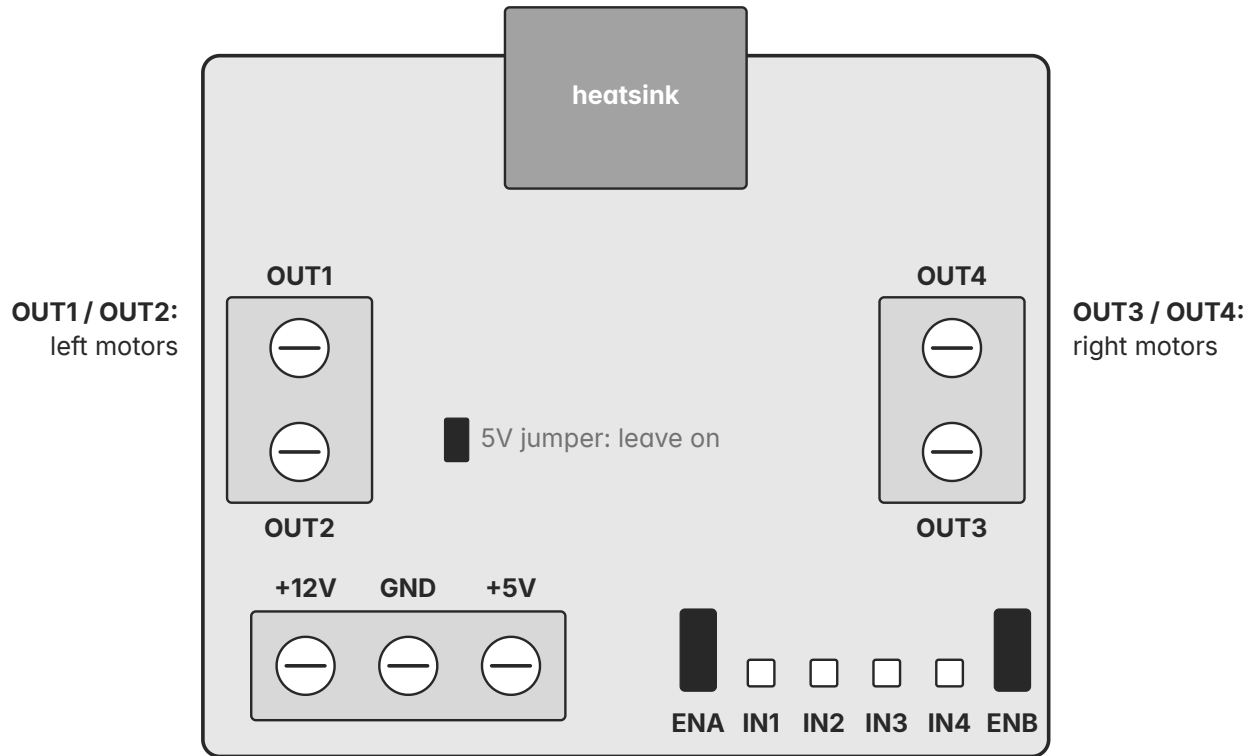
Black squares: the pins this car uses. The ~ mark means the pin can control speed.

FIGURE 4.1 The board, with every part this build uses labelled: the USB socket, the ON and L lights, pins 2, 3, 4, 5, 6 and 9 to 12, and the 5V, GND and Vin pins.

Find it (Figure 4.1). Parent reads; child points; parent ticks.

- ☐ The USB socket, where the cable plugs in.
- ☐ The ON light. It lights whenever the board has power.
- ☐ The L light. The sketch uses it to say it's running.
- ☐ Pins 2, 3 and 4, on the long row of holes marked DIGITAL.

- ☐ Pins 5 and 6. Look for a small wavy mark, , printed beside them.
- ☐ Pins 9, 10, 11 and 12, further along the same row.
- ☐ The pins marked 5V, GND and Vin, on the shorter row on the other side.



Power screws: +12V, GND, +5V. Signal pins: ENA IN1 IN2 IN3 IN4 ENB.
Black blocks on ENA and ENB: the two caps. They come off in Stage B.

FIGURE 4.2 The motor driver. The four motor screws OUT1 to OUT4, the power screws marked +12V, GND and +5V, the six signal pins ENA, IN1, IN2, IN3, IN4 and ENB, and the two caps on ENA and ENB.

Find it (Figure 4.2).

- ☐ The two blue screw blocks for the motors, marked OUT1 and OUT2 on one side and OUT3 and OUT4 on the other.
- ☐ The three-screw block for power, marked +12V, GND and +5V. (Some boards print 12V or VMS instead of +12V; it's the screw at the end, furthest from +5V.)
- ☐ The row of six pins marked ENA, IN1, IN2, IN3, IN4 and ENB.
- ☐ The two small plastic caps sitting on the ENA and ENB pins. You'll take them off in Stage B.
- ☐ The black metal fin, the heatsink. It can get warm while the car drives.

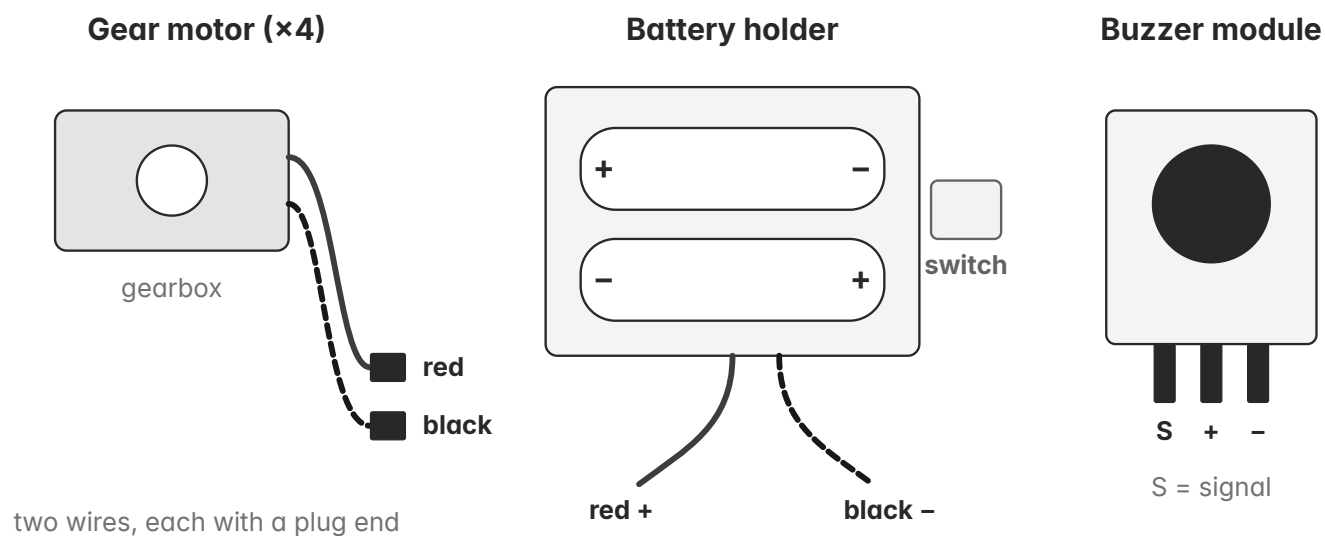
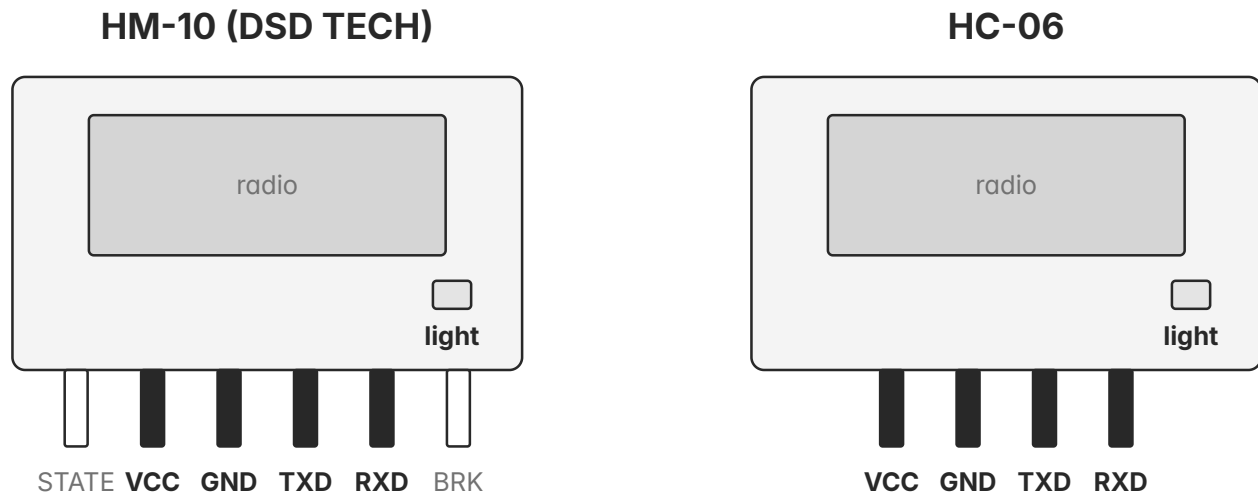


FIGURE 4.3 The small parts. A gear motor with its two wires, the battery holder with its switch and its red and black leads, and the buzzer module with its three pins.

Find it (Figure 4.3).

- ☐ On each of the four motors: two wires, one red and one black, each ending in a plug. If red and black look alike to you, the checker reads them out.
- ☐ On the battery holder: the on/off switch, and the two leads, red (+) and black (-).
- ☐ Inside the holder: the + and - marks that show which way each cell goes.
- ☐ On the buzzer module: three pins, marked something like S (signal), + and -.



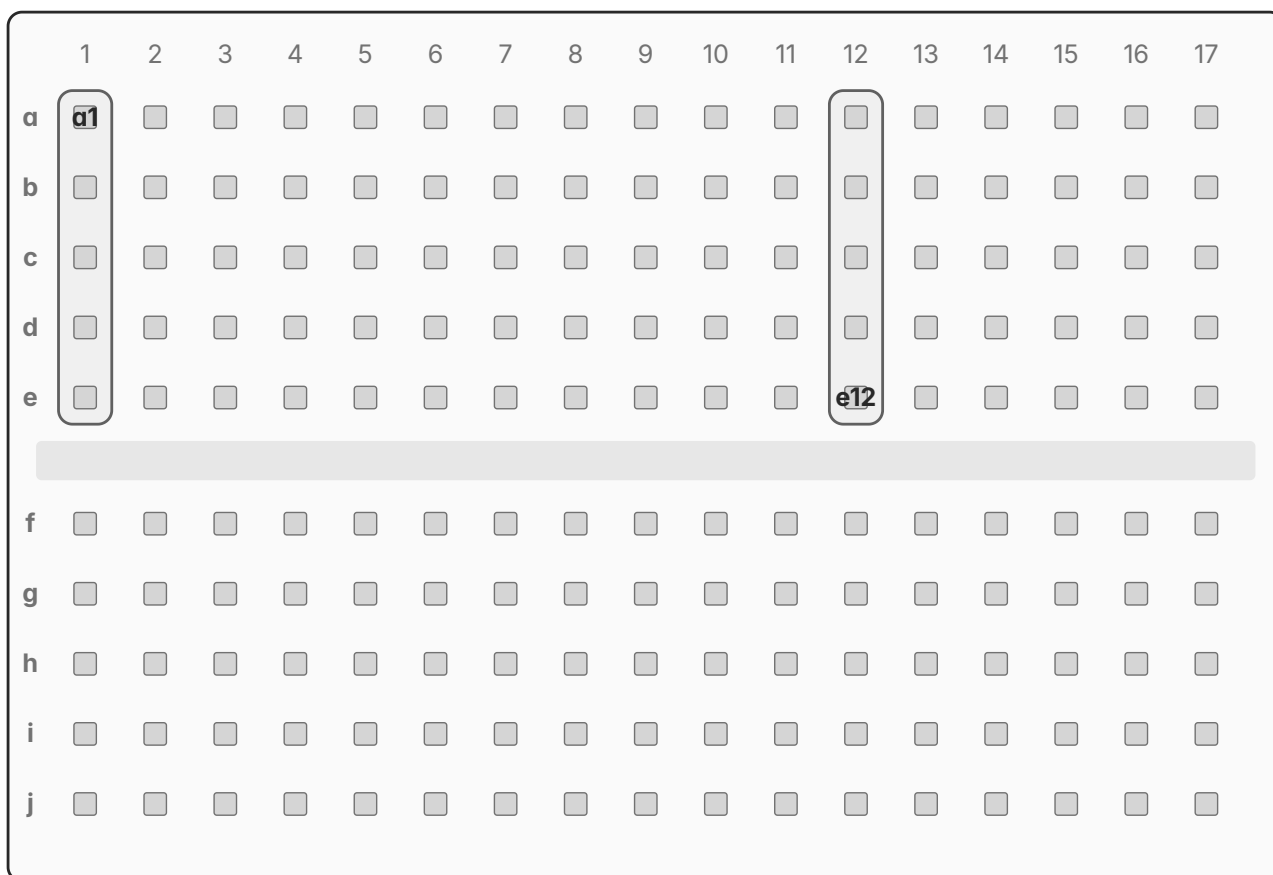
Black pins are used by this car. Unused: STATE and BRK on the HM-10.

FIGURE 4.4 The two Bluetooth modules side by side. Both have VCC, GND, TXD and RXD, and a small status light.

Find it (Figure 4.4).

- ☐ VCC and GND, the power pins.
- ☐ TXD, the pin the module talks on.
- ☐ RXD, the pin the module listens on.
- ☐ The small status light on the module.

Each numbered column of five holes, a to e, is joined inside. f to j is a separate group.

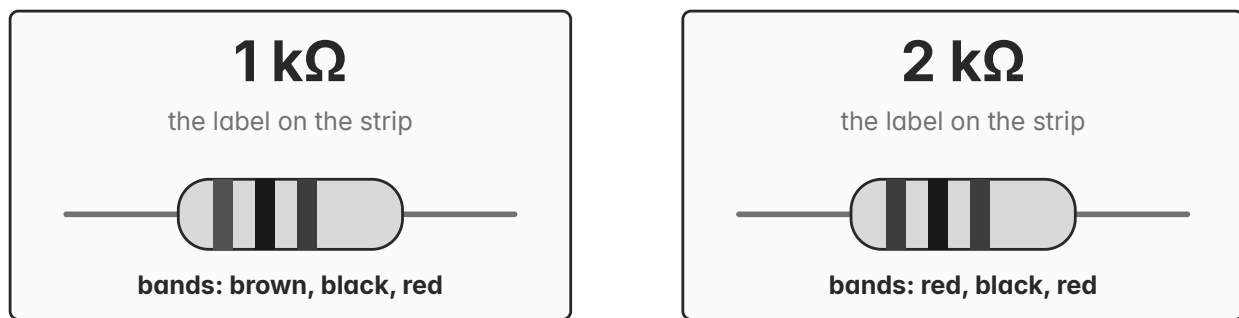


Shaded: column 1 (holes a1 to e1) and column 12 (a12 to e12). Each is one joined strip.

FIGURE 4.5 The mini breadboard. Each column of five holes, a to e, is joined inside. Holes are named by row letter and column number, like a1.

Find it (Figure 4.5 and Figure 4.6).

- ☐ The row letters a to e, and the column numbers along the edge.
- ☐ Hole a1 and hole e12. Put a finger on each.
- ☐ The 1 k Ω resistor, on its labelled strip.
- ☐ The 2 k Ω (or 2.2 k Ω) resistor, on its labelled strip.



Read the label first. The bands are a second check (a 2.2 kΩ reads red, red, red).

FIGURE 4.6 The two resistors, each on its labelled paper strip. The 1 kΩ has bands brown, black, red; the 2 kΩ has bands red, black, red.

TALK ABOUT IT

“Point to the module’s two letter pins. Which one talks, and which one listens?”

PARENT: LISTEN FOR:

TXD talks and RXD listens. Pointing to the right two pins is enough; the names come back in Stage C.

CHAPTER 6 • Stage A • The board: put the sketch on it

PARENT P1

Download the Arduino IDE from arduino.cc/en/software and install it. This book was written with version 2.3. A newer 2.x version works the same way.

PARENT P2

Plug the board into the laptop with its USB cable. The board’s ON light comes on.

PARENT P3

Open the Arduino IDE. In the **Tools** menu, choose **Board**, then **Arduino AVR Boards**, then **Arduino Uno**. If the IDE offers to install “Arduino AVR Boards”, say yes.

PARENT P4

In **Tools** → **Port**, choose the board. To be sure which one it is, unplug the board, look at the list, plug it back in, and pick the one that appeared.

🔧 TEST IT

YOU SHOULD SEE:

a port appears when you plug the board in.

A INSTEAD:

no new port appears, even though the ON light is lit.

MEANING:

the laptop can't talk to the board. Either the cable only charges (some USB cables have no data wires inside), or the board is a clone that needs a driver.

FIX:

try another USB cable first, one you know carries data. If that doesn't help and your board has a chip marked CH340 near the USB socket, install the CH340 driver from the chip maker, WCH. The link is on the Stage A test page, troniction.com/go/car-test-a.

PARENT P5

Unzip the sketch you downloaded from troniction.com/go/car-sketch. Keep the folder called `car` with both files inside it, `car.ino` and `pitches.h`.

PARENT P6

In the IDE, choose **File → Open** and open `car.ino`. The sketch opens in a window.

PARENT P7

Unplug the board. Leave the IDE open with the sketch in it.

CHILD A1

Plug the USB cable into the board and into the laptop. Look for the ON light.

PARENT A2

Read the name at the top of the IDE window, beside the board picker. It should say **Arduino Uno**. If it doesn't, choose it again (step P3 and P4).

CHILD A3

Click **Upload**: the round button with an arrow pointing right, at the top left. Then wait. Don't unplug anything.

CHILD A4

Watch the message area at the bottom of the window. When the upload has worked, it says **Done uploading**. While it uploads, the lights on the board flicker. That's normal.

🕒 TEST IT

YOU SHOULD SEE:	"Done uploading".
A INSTEAD:	an error in orange or red text, such as "not in sync" or "port busy".
MEANING:	the IDE couldn't reach the board.
FIX:	check that Tools → Board says Arduino Uno and Tools → Port is the board's port. Close any other program that might be using the board. Unplug the cable, plug it back in, and press Upload again.

CHILD A5

Open the **Serial Monitor**: the magnifying-glass button at the top right of the window. A panel opens at the bottom. In its menu of speeds, choose **9600 baud**.



FIGURE 6.1 The Serial Monitor after the upload. It shows the words Car ready, and its speed is set to 9600 baud.

🕒 TEST IT

YOU SHOULD SEE:

`Car ready` in the Serial Monitor. (The L light also comes on and stays on.)

A INSTEAD: the L light blinks slowly, on and off, forever, and the Serial Monitor is empty.

MEANING: the board is still running the sample sketch it came with. The upload didn't happen.

FIX: press Upload again and wait for "Done uploading".

B INSTEAD: strange symbols in the Serial Monitor instead of words.

MEANING: the Serial Monitor's speed isn't 9600.

FIX: choose 9600 baud. Then press the small button on the board marked RESET. It restarts the board, and `Car ready` prints again.

C INSTEAD: the L light is on, but the Serial Monitor is empty.

MEANING: nothing is proved yet. `Car ready` is the only proof that this sketch is on the board. The L light can be on for other reasons.

FIX: check the speed is 9600, then press RESET on the board. If `Car ready` still doesn't appear, press Upload again (A3) and wait for "Done uploading".

🗨 TALK ABOUT IT

"The screen says `Car ready`. Which box have we just proved works?"

PARENT: LISTEN FOR:

the board, and the laptop talking to it. Not the wheels yet: nothing else is connected.

CHAPTER 7 • Stage B1 • Chassis and motors

⚠ WARNING

Before you start: the battery cells stay out, with the parent, until Chapter 9. Switch the battery holder off now and leave it off.

TOGETHER B1

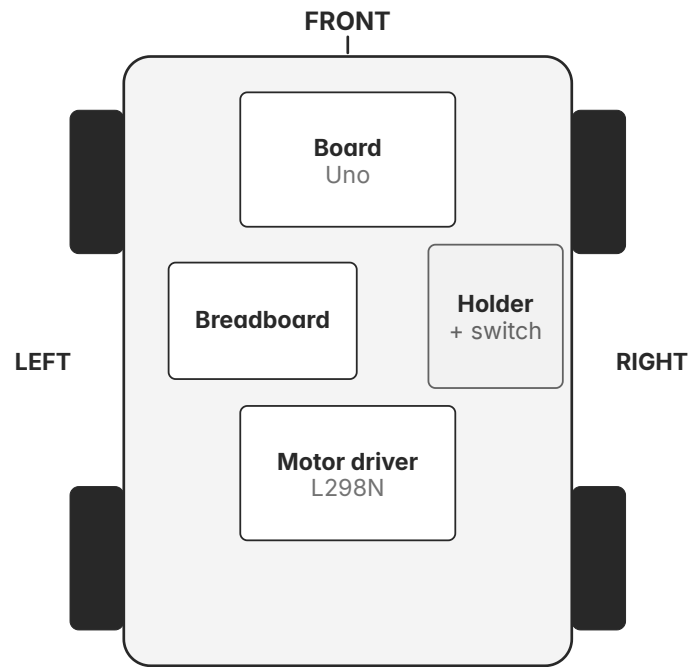
Open your chassis kit's instruction sheet. It decides how the plates and motors fit together.

CHILD B2

Fix the four motors to the bottom plate the way the kit sheet shows. Point every motor's wires toward the middle of the car.

CHILD B3

Push a wheel onto each motor's shaft, all the way.



One possible layout. Your kit's holes decide the exact places.

FIGURE 7.1 The layout from above. The board sits near the front, the breadboard and the battery holder in the middle, and the motor driver near the back. The end marked FRONT is at the top.

CHILD B4

Put a small piece of tape on the front end and write FRONT. "Left" and "right" now mean the car's left and right, as if you sat in it facing the front.

CHILD B5

Fix the motor driver, the board, the breadboard and the battery holder to the top plate, as in **Figure 7.1**. Use the kit's screws, or double-sided tape. Put the holder where you can reach its switch.

CHILD B6

Fix the top plate onto the bottom plate. Bring all eight motor wires up so they reach the motor driver.

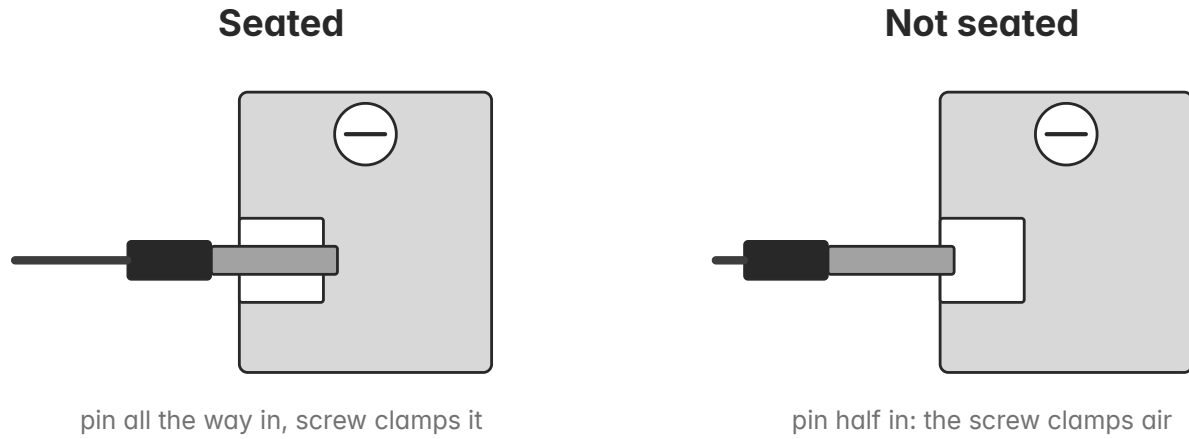


FIGURE 7.2 A wire in a screw terminal. Left: seated, with the metal pin all the way in and the screw clamping it. Right: not seated, with the pin only half in.

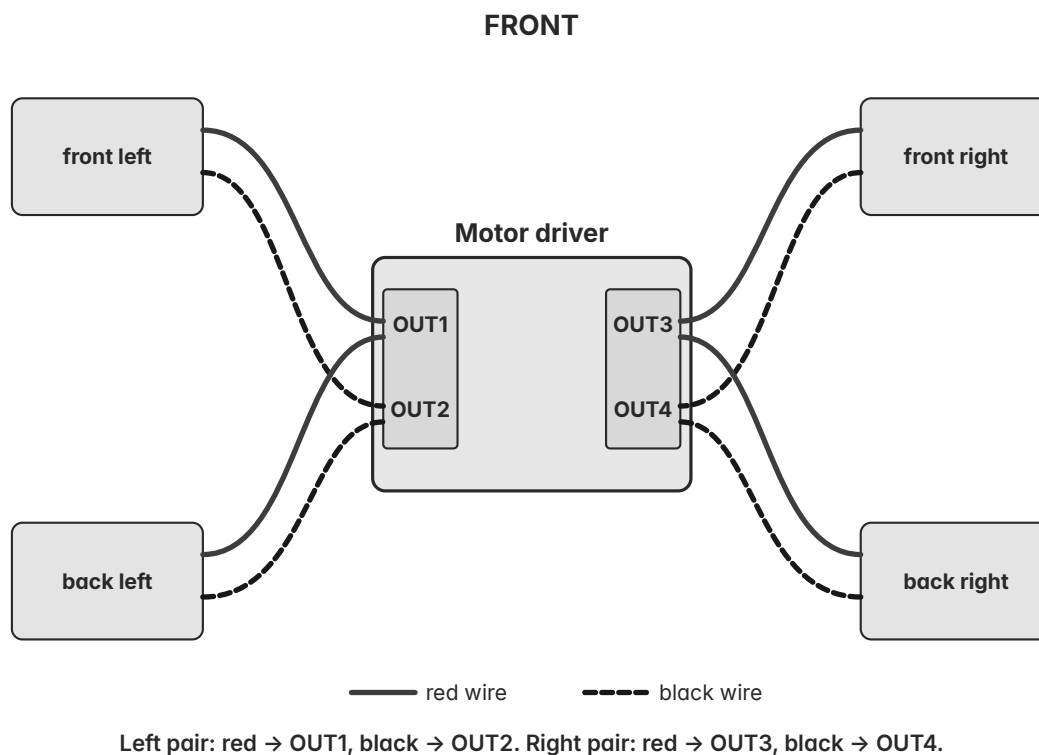


FIGURE 7.3 The motors to the motor driver, wired straight. Both left motors: red wire to OUT1, black to OUT2. Both right motors: red to OUT3, black to OUT4.

- CHILD B7** Left side. Turn both screws of the block marked OUT1 and OUT2 to the left a few turns, so the holes open.
- CHILD B8** Push the **red** wires of **both** left motors into **OUT1**, side by side.
- CHILD B9** Push the **black** wires of both left motors into **OUT2**.
- CHILD B10** Tighten both screws, turning to the right until they're firm.
- CHILD B11** Tug each of the four wires gently. None should come out.
- PARENT B12** Check against **Figure 7.3**: both left motors, red in OUT1, black in OUT2.
- CHILD B13** Right side. Open both screws of the block marked OUT3 and OUT4.
- CHILD B14** Push the **red** wires of both right motors into **OUT3**.
- CHILD B15** Push the **black** wires of both right motors into **OUT4**.
- CHILD B16** Tighten both screws. Tug each of the four wires.

Check: both right motors, red in OUT3, black in OUT4 (the same figure as B12).

🕒 TEST IT

YOU SHOULD SEE:	all eight motor wires stay in when you tug them.
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A INSTEAD:	a wire slides out.
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MEANING:	the screw was clamping nothing, or only the plastic.
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FIX:	loosen that screw, push the metal pin in all the way, so no metal shows outside the hole, and tighten again. Tug again.
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CHAPTER 8 • Stage B2 • Motor driver to the board

⚠ WARNING

All power off before you start: the USB cable unplugged and the battery switch off. The cells are still out.

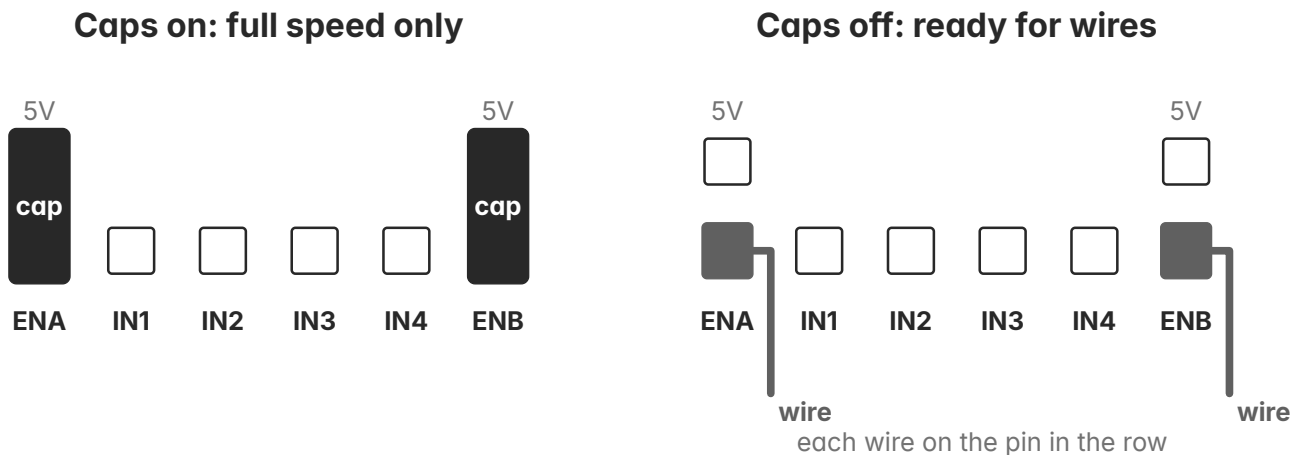


FIGURE 8.1 The ENA and ENB pins with their caps on, and with the caps off. With the caps off, each speed pin is free for a wire.

CHILD B18

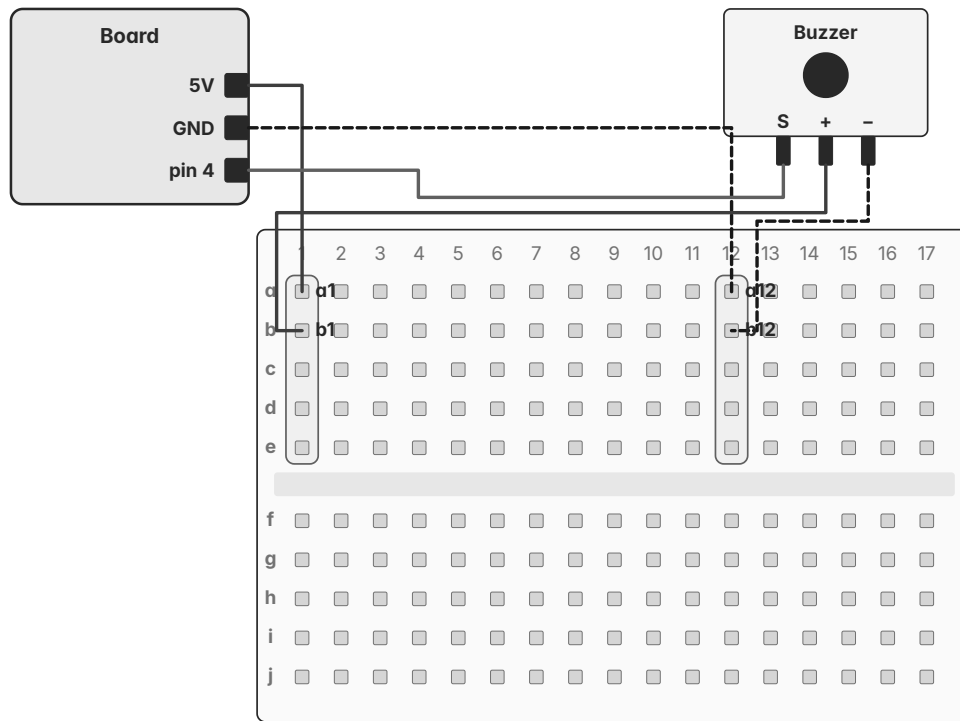
Pull the cap off the **ENA** pins, straight up, with your fingers or small pliers. Put it in a bag so it doesn't get lost.

CHILD B19

Pull the cap off the **ENB** pins the same way. Leave the cap near the power screws where it is.

PARENT B20

Check: no cap on ENA or ENB. Each cap covered two pins: the ENA (or ENB) pin, in the row with IN1 to IN4, and a 5V pin behind it. The speed wire will go on the pin **in the row**.



5V to column 1 (solid). GND to column 12 (dashed). Buzzer S to pin 4.

FIGURE 8.2 The buzzer and the breadboard's power. The board's 5V goes to column 1 and GND to column 12. The buzzer's plus goes to column 1, its minus to column 12, and its S pin to the board's pin 4.

CHILD B21 With a male-to-male jumper: the board's **5V** pin to breadboard hole **a1**. Column 1 is now the 5V column.

CHILD B22 With a male-to-male jumper: one of the board's **GND** pins, on the same short row as 5V, to hole **a12**. Column 12 is now the GND column.

CHILD B23 With a male-to-female jumper: the buzzer's **+** pin to hole **b1**.

CHILD B24 With a male-to-female jumper: the buzzer's **–** pin to hole **b12**.

CHILD B25 With a male-to-female jumper: the buzzer's **S** pin to **pin 4** on the board.

PARENT B26 Check against **Figure 8.2**: 5V in a1, GND in a12, buzzer + in b1, – in b12, S on pin 4. Column 1 holds only 5V wires; column 12 only GND wires.

⚠ WARNING

5V and GND must never touch. Never put a 5V wire and a GND wire in the same column. That would short the board's power. If you find one, switch everything off before you move it.

CHILD B27

Plug in the USB cable. Open the Serial Monitor. Choose **9600 baud** and **No Line Ending**.

CHILD B28

Type **V** and press Enter. Then type **S** and press Enter.

🔧 TEST IT

YOU SHOULD SEE:

Got V from USB, and the horn sounds until you type S.

A INSTEAD:

Got V from USB, but no sound.

MEANING:

the buzzer's wires. Its power goes through columns 1 and 12, and its S wire to pin 4.

FIX:

unplug the USB cable. Check B21 to B25 against **Figure 8.2**, then test again.

B INSTEAD:

one short beep, and Got (newline) from USB.

MEANING:

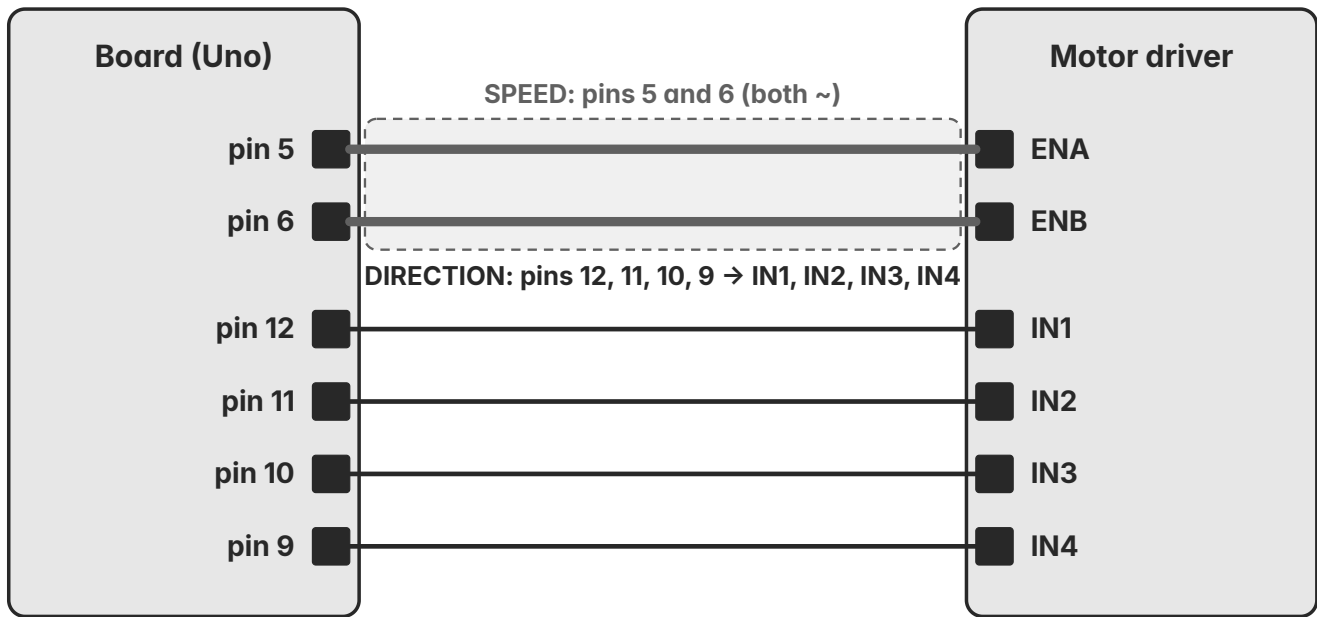
the Serial Monitor is adding a "new line" letter, and the car treats it as stop.

FIX:

choose No Line Ending.

⚠️ WARNING

All power off: the USB cable unplugged and the battery switch off.



Male end in the board's socket; female end on the motor driver's pin.

FIGURE 8.3 The motor driver to the board. Speed wires: ENA to pin 5 and ENB to pin 6. Direction wires: IN1 to pin 12, IN2 to 11, IN3 to 10 and IN4 to 9.

CHILD B29 ENA on the motor driver to **pin 5** on the board.

CHILD B30 ENB to **pin 6**.

CHILD B31 IN1 to **pin 12**.

CHILD B32 IN2 to **pin 11**.

CHILD B33 IN3 to **pin 10**.

CHILD B34 IN4 to **pin 9**.

TABLE 8.1 The six signal wires. Speed on 5 and 6; direction on 9 to 12, in reverse order

MOTOR DRIVER PIN	BOARD PIN	DOES
ENA	5	Left side's speed
ENB	6	Right side's speed
IN1	12	Left side's direction
IN2	11	Left side's direction
IN3	10	Right side's direction
IN4	9	Right side's direction

Check all six against **Table 8.1**, one at a time, reading each pair aloud: “ENA, pin 5.” The child points to both ends of the wire.

CHAPTER 9 • Stage B3 • Power, and the wheels test

⚠ WARNING

The battery cells stay out, and the switch stays off, through all of these steps.

Red: +12V screw and on to Vin. Black: GND screw and on to GND.

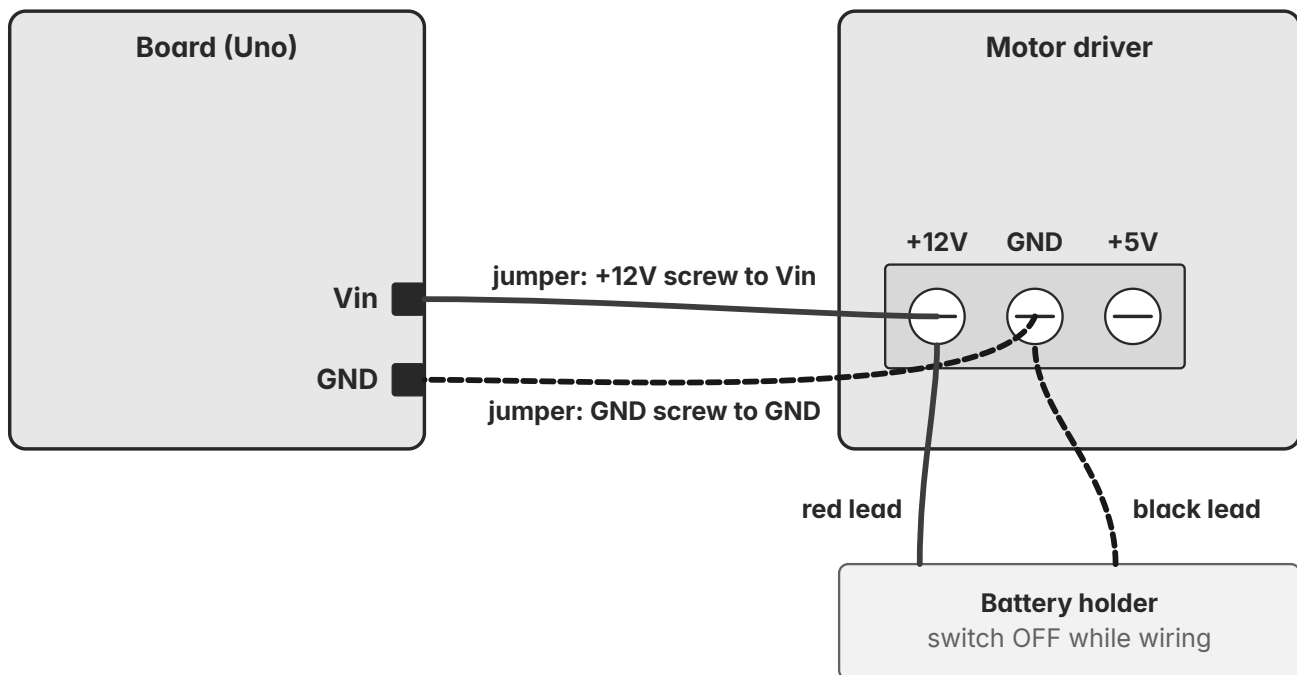


FIGURE 9.1 The battery to the motor driver and the board. Red: the holder’s lead to the +12V screw, and a jumper from that screw to Vin. Black: the holder’s lead to the GND screw, and a jumper from that screw to a GND pin.

CHILD B36

Check that the battery holder’s switch is **off**.

CHILD B37

Loosen the motor driver’s **+12V** screw a few turns.

CHILD B38

Push the holder’s **red** lead and one end of a male-to-male jumper into it, side by side.

CHILD B39

Tighten the +12V screw.

CHILD B40

Push the other end of that jumper into the board’s **Vin** pin.

CHILD B41Loosen the motor driver's **GND** screw.**CHILD B42**Push the holder's **black** lead and one end of a second male-to-male jumper into it.**CHILD B43**

Tighten the GND screw.

CHILD B44Push the other end of that jumper into the board's free **GND** pin, next to Vin.**PARENT B45**

Check: red lead and a jumper in +12V, the jumper on to Vin; black lead and a jumper in GND, the jumper on to GND. Then the child tugs each of the four ends gently. None should come out.

The checklist before power. One reads, one checks. Tick each line.

- ☐ **Battery polarity:** red to +12V and Vin; black to GND.
- ☐ **No stray metal** touching anything.
- ☐ **Grounds joined:** the motor driver's GND screw to the board's GND.
- ☐ **Every motor wire seated** (tug each one).
- ☐ **Column 1 only 5V; column 12 only GND.**
- ☐ **The car is on a box**, all four wheels off the table.

Our guesses for F: left wheels ☐ forward ☐ backward · right wheels ☐ forward ☐ backward

TOGETHER B46

The checklist. One reads, one checks, every line, out loud. Tick each one.

☐ **TALK ABOUT IT**

Before the cells go in: "Point to the wire that will carry the most power. Why that one?"

PARENT: LISTEN FOR:

a battery lead, the red or the black one at the holder. "Because it feeds everything" is right.

⚠ WARNING

The parent puts the cells in. Check the switch is off first. Match each cell's + end to the + mark inside the holder. A cell in backwards can damage the motor driver and the board.

**PARENT B47**

Check the switch is off. Put the two cells in, each matching the + mark in the holder.

**CHILD B48**

Switch the holder **on**. Look at the board's ON light and the motor driver's small light. No wheel should move.

⚙️ TEST IT
YOU SHOULD SEE:

the board's ON light and the motor driver's light both come on, and nothing gets hot.

A INSTEAD:

no light anywhere.

MEANING:

no power is reaching the motor driver or the board.

FIX:

switch off. The parent checks the cells are the right way round and pushed fully in. Then check the red and black leads are clamped in their screws (B38, B42).

B INSTEAD:

the motor driver's light is on, but the board's ON light is off.

MEANING:

the battery reaches the motor driver but not the board.

FIX:

switch off; the parent takes the cells out. Check B37 to B44: the jumper from +12V to Vin, and the jumper from GND to GND. Tug both ends of each.

C INSTEAD:

something feels hot, smells hot, or the lights flicker oddly.

MEANING:

something is wired wrongly, most likely the battery leads swapped.

FIX:

switch off at once. The parent takes the cells out. Go through the checklist again, starting at line 1.



FIGURE 9.2 The Serial Monitor’s two settings for the wheels test: No Line Ending, and 9600 baud. You type in the box at the top and press Enter.

CHILD B49

Plug the USB cable into the board and the laptop. Open the Serial Monitor. Check it shows 9600 baud and **No Line Ending**.

🗉 TALK ABOUT IT

“Which way will the left wheels turn when we type F? And the right wheels? Tick both guesses on the checklist.”

PARENT: LISTEN FOR:

any guess is fine. What matters is checking it. If any wheels go the wrong way, the test box says which wires to swap.

CHILD B50

Type **F** and press Enter. Watch all four wheels. Then type **S** and press Enter.

🕒 TEST IT

YOU SHOULD SEE:

Got F from USB, and all four wheels turn forward.

A INSTEAD: all four wheels turn backwards.

MEANING: every motor is wired the other way round for this sketch. That's normal. It depends on how your motors were made, and nothing is broken.

FIX: type S, switch off. On all four motors, swap red and black at the motor driver. Switch on and type F again.

B INSTEAD: one side's two wheels turn backwards.

MEANING: that side's motors are the other way round.

FIX: type S, switch off. On that side only, swap red and black on both motors. Switch on and type F again.

C INSTEAD: one wheel turns backwards and the other wheel on its side turns forwards.

MEANING: that one motor's wires are the other way round.

FIX: type S, switch off, and swap red and black on the motor that turns backwards. Type F again.

D INSTEAD: Got F from USB appears, but no wheel moves.

MEANING: the board got the letter, so the problem is in the wheels box or its power.

FIX: is the switch on? Are the cells in? Are the battery leads and both jumpers clamped (B37 to B44)? Are the six signal wires on the right pins (B29 to B34)? If the wheels twitch and stop and the Serial Monitor shows Got (newline) from USB, choose No Line Ending (Chapter 12).

CHILD B51

Type **B**, then **S**. All four wheels turn backwards, and the buzzer beeps while they do.

CHILD B52

Type **L**, then **S**. The left wheels turn backwards and the right wheels forwards: on the floor, the car would spin to the left. Then **R**, then **S**: the other way round.

⌚ TEST IT

YOU SHOULD SEE: L spins the car to the left.

A INSTEAD: F is right, but L spins the car to the right.

MEANING: the left motors are on OUT3 and OUT4, and the right ones are on OUT1 and OUT2.

FIX: type S, switch off. Move the left motors' wires to OUT1 and OUT2, and the right motors' to OUT3 and OUT4. Then go back to B50 and type F. All four wheels will probably turn backwards now; the first row of the F test fixes that.

CHILD B53 Type F. While the wheels turn, type 1, then 9, then S.

⌚ TEST IT

YOU SHOULD SEE: speed 1 is clearly slower than speed 9.

A INSTEAD: every speed is the same.

MEANING: a cap is still on ENA or ENB, or a speed wire is on a pin without the  mark.

FIX: switch off. Check B18 and B19 (caps off) and B29 and B30 (pins 5 and 6).

🗨️ TALK ABOUT IT

After the speeds: "Speed 1 crawls and 9 runs. What is the pin doing differently?"

PARENT: LISTEN FOR:

"it's on for less of the time" or "it gives less push". A guess is fine. Part 2 has the answer.

CHILD B54 Type S. Then unplug the USB cable from the board. Look at the board's ON light.

🔧 TEST IT

YOU SHOULD SEE:

the ON light stays on after the USB cable comes out.

A INSTEAD:

the ON light goes out.

MEANING:

the battery reaches the motor driver but not the board. The board was running on the laptop's power all along.

FIX:

switch off; the parent takes the cells out. Redo B37 to B44: the jumper from the +12V screw to Vin, and the jumper from the GND screw to GND. Tug both ends of each. Then the cells go back in and you test again.

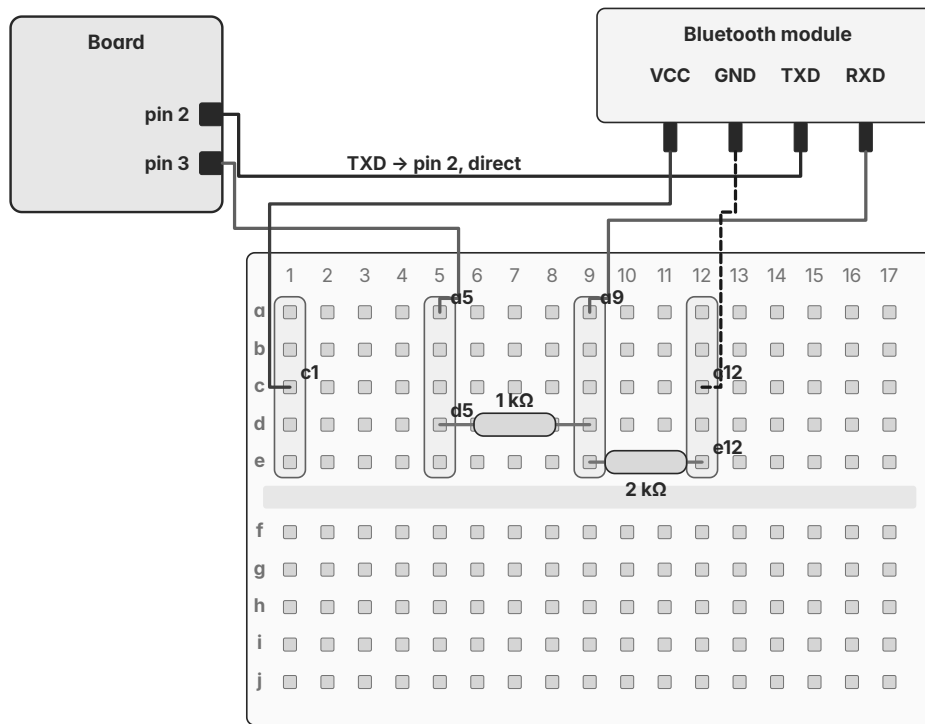
CHAPTER 10 • Stage C • The Bluetooth module

⚠ WARNING

All power off before you start: type S, unplug the USB cable, and switch the battery holder off. The module's wires go near the board's 5V pin, and a slip with the power on can damage the module.

CHILD C1

Check: the USB cable is out, and the holder's switch is off.



Columns: 1 = 5V; 5 = from pin 3; 9 = where the resistors meet, to RXD; 12 = GND.

FIGURE 10.1 The Bluetooth module and the two resistors. Pin 3 goes to column 5, through the 1 kΩ resistor to column 9, where the module's RXD connects; the 2 kΩ resistor joins column 9 to GND in column 12. The module's TXD goes straight to pin 2. VCC goes to column 1 and GND to column 12.

- CHILD C2** The **1 kΩ** resistor (check its label): one leg in hole **d5**, the other in hole **d9**.
- CHILD C3** The **2 kΩ** resistor (or the 2.2 kΩ): one leg in hole **e9**, the other in hole **e12**, the GND column.
- CHILD C4** With a male-to-male jumper: the board's **pin 3** to hole **a5**.
- CHILD C5** With a male-to-female jumper: the module's **VCC** to hole **c1**, the 5V column.
- CHILD C6** With a male-to-female jumper: the module's **GND** to hole **c12**, the GND column.
- CHILD C7** With a male-to-female jumper: the module's **TXD** straight to the board's **pin 2**.
- CHILD C8** With a male-to-female jumper: the module's **RXD** to hole **a9**, the column where the two resistors meet.

PARENT C9

Check, reading each line aloud while the child points (the figure is with C2 to C7):

- The 2 k Ω from e9 to e12. This is the only check it gets: no test can see it. The child points to both legs.
- 1 k Ω from d5 to d9.
- Pin 3 to a5.
- VCC to c1, GND to c12.
- TXD to pin 2.
- RXD to a9.
- Nothing from the module goes to pins 0 or 1.

▲ CHILD C10 Switch the holder on. Look at the module's light.

⌚ TEST IT

YOU SHOULD SEE: the module's light keeps blinking on and off (an HM-10 blinks about once a second).

A INSTEAD: the light stays off.

MEANING: the module has no power.

FIX: switch off. Check the module's VCC is in column 1 and its GND in column 12 (C5, C6), and that the board's 5V jumper is still in a1 and its GND jumper in a12 (B21, B22). Then switch on again.

B INSTEAD: the board's ON light goes out or flickers when you switch on.

MEANING: a short: something joins 5V to GND.

FIX: switch off at once. Look for a 5V wire in the GND column, or a GND wire in the 5V column.

TABLE 10.1 Test C2 with each module. Only these rows differ

	HM-10	HC-06
Phone	Android with Chrome, or iPhone with Bluefy	Android only
Pair in the phone's Bluetooth settings?	No. Never	Yes, first, with the code 1234

	HM-10	HC-06
Connect from	The remote: troniction.com/go/car-remote	The Serial Bluetooth Terminal app
How you know it's connected	The remote says <i>connected</i> ; the module's light goes steady	The app says <i>Connected</i> ; the module's light goes steady

TEST C2 • HM-10 ONLY

CHILD C11 On the phone, open **Chrome** (Android) or **Bluefy** (iPhone). Go to troniction.com/go/car-remote.

CHILD C12 Tap **Connect**. If the phone asks to allow Bluetooth or nearby devices, the parent reads the question and says yes.

CHILD C13 A list of devices appears. Tap your module: it's usually called **HMSoft**. Some modules use another name, such as **DSD TECH**; the name is on the module's bag or listing.

🔧 TEST IT

YOU SHOULD SEE: the remote says *connected*, and the module's light goes from blinking to steady.

A INSTEAD: on Android, the list says no devices found.

MEANING: Chrome isn't allowed to look for Bluetooth devices.

FIX: turn on the phone's **Location**, and in the phone's app settings, give Chrome the **Nearby devices** permission. Then tap Connect again.

B INSTEAD: on an iPhone, nothing happens when you tap Connect, or the page says Bluetooth isn't supported.

MEANING: you're in Safari, which can't use Bluetooth from a web page.

FIX: open the same address in the **Bluefy** browser.

TEST C2 • HC-06 ONLY

CHILD C11 On the Android phone, open **Settings** → **Bluetooth** and scan for new devices. Your module appears, usually as **HC-06** (some are called **linvor**). Tap it.

CHILD C12

When the phone asks for a PIN, type **1234**. (If 1234 is refused, try **0000**.) The module now shows as paired.

CHILD C13

Open the **Serial Bluetooth Terminal** app. Open its menu, choose **Devices**, then the **Bluetooth Classic** tab, and tap your module. The app says *Connected*.

 TEST IT**YOU SHOULD SEE:**

the app says *Connected*, and the module's light goes from blinking to steady.

A INSTEAD:

the module never appears when the phone scans.

MEANING:

the module has no power, or it's already connected to another phone.

FIX:

check that its light is blinking (test C1). Turn off Bluetooth on any other phone that connected to it before.

B INSTEAD:

the module is paired, but the app can't connect.

MEANING:

another app, or another phone, is holding the connection.

FIX:

close other Bluetooth apps, switch the car off and on, and connect again from the app.

 TALK ABOUT IT

"The light went steady. Does that mean the car will move? How could we check?"

PARENT: LISTEN FOR:

"not yet", or "we'd have to press a button and watch". Stage D checks it.

CHAPTER 11 • Stage D • The round trip, then drive

 WARNING

The car stays on its box until the round-trip test has passed. It will move when the letter arrives.

**CHILD D1**

Car on its box. Switch on. Plug in the USB cable and open the Serial Monitor at **9600**.

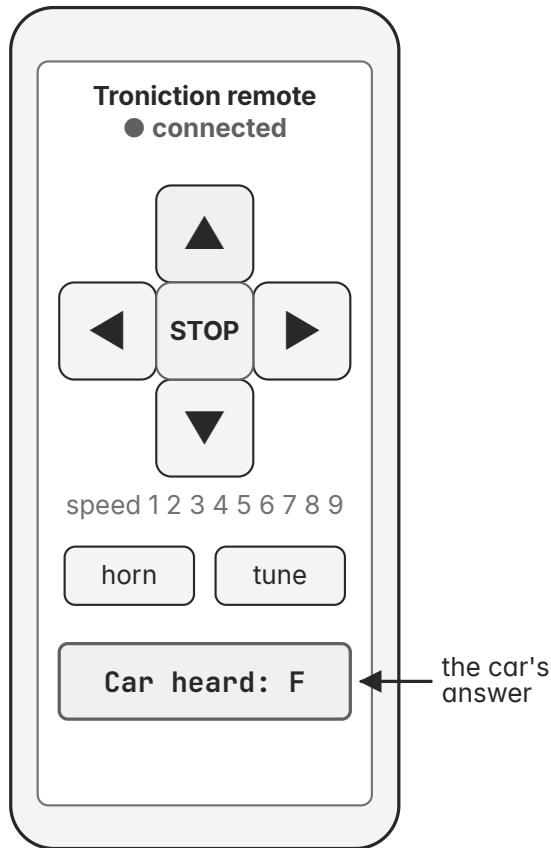
CHILD D2

Connect the phone to the module, as in test C2. The module's light is steady.

ROUND TRIP · HM-10 ONLY

CHILD D3

On the remote, press and hold **Forward** for a second, then let go.



Drawn mock-up of the planned remote

FIGURE 11.1 The remote after pressing Forward. Under the buttons, its reply line shows Car heard: F, the car's answer.

ROUND TRIP · HC-06 ONLY

CHILD D3

In Serial Bluetooth Terminal, open **Settings**, then the **Send** section, and set **Newline** to **None**. Go back to the terminal.

CHILD D4

Type **F** in the box at the bottom and tap the send arrow. Then type **S** and send it.



FIGURE 11.2 The Serial Monitor during the round trip. Each letter from the phone is shown as it arrives: Got F from phone, then Got S from phone.

CHILD D5

Read both screens aloud: the Serial Monitor on the laptop, and the phone. The parent checks them against **Figure 11.2**.

TEST IT

YOU SHOULD SEE:

the Serial Monitor shows `Got F from phone`, the phone shows `Car` `heard: F`, and the wheels turn forward until the S arrives.

A INSTEAD:

`Got F from phone` appears, and the wheels turn, but the phone never shows `Car heard`.

MEANING:

the letter arrives, but the answer doesn't get back. The answer travels from pin 3, through the 1 k Ω resistor, to the module's RXD.

FIX:

all power off: unplug the USB cable and switch off. Check the 1 k Ω (C2), the pin 3 wire (C4) and the RXD wire (C8) against the figure in Chapter 10. Then test again.

B INSTEAD:	the phone is connected, but nothing at all appears in the Serial Monitor.
MEANING:	the letter doesn't reach the board. The wire from the module's TXD to pin 2 is missing or on the wrong pin, or TXD and RXD are swapped.
FIX:	all power off. Check C7 (TXD to pin 2) and C8 (RXD to a9).
C INSTEAD:	with an HM-10, the wires check out, but each press shows only a line with an odd code in brackets, such as <code>Got (code ...) from phone</code> , and never <code>Got F</code> .
MEANING:	the module talks at a different speed from the sketch. The sketch expects 9600, the factory speed of the HM-10. Some HM-10s with newer software (versions V700 to V709) are reported to start at 115200 instead.
FIX:	near the top of the sketch, change the module's speed, <code>BT_BAUD</code> , from <code>9600</code> to <code>115200</code> , and upload it again (Chapter 6). If <code>Got F from phone</code> now appears, that was it. The car drives at that speed, but the board can miss a letter now and then. To set the module back to 9600 for good, it needs the setup command <code>AT+BAUD0</code> (and <code>AT+VERS?</code> reads its software version): <i>Make It Connect</i> has the bridge sketch and the steps, at troniction.com/go/car-mic .
D INSTEAD:	the letters arrive and are answered, but the wheels don't turn.
MEANING:	the phone, the module and the board all work. The problem is in the wheels box or its power.
FIX:	is the holder switched on? Then redo the wheels test from Chapter 9.

☐ TALK ABOUT IT

“The letter came back. Which boxes do we know work now?”

PARENT: LISTEN FOR:

all four: the phone, the Bluetooth module, the board and the wheels.

TABLE 11.1 The letters the car understands

LETTER	WHAT THE CAR DOES
F	Forward
B	Backward, with a beep
L	Spin left
R	Spin right
S	Stop (any letter the car doesn't know also stops it)
1 to 9	Speed, slowest to nearly fastest; it keeps moving at the new speed
q	Fastest
V	Horn, until the next letter
X	<i>Happy Birthday</i> (see the warning)

⚠ WARNING

Stop the car before you play the tune. While *Happy Birthday* plays, about 16 seconds, the car keeps doing what it was doing, and it can't hear any letter you send. When the song ends, it plays again, until a new letter arrives. So: S first, then X, and S again to end the song.

CHILD D6 Send S, then unplug the USB cable. The holder stays switched on.

CHILD D7 Lift the car off its box and put it on the floor.

TOGETHER D8 Drive. Try speed 1 and speed 9, the horn, and a spin each way.

🗨 TALK ABOUT IT

"It drifts a little to one side on the floor. Is something wired wrong?"

PARENT: LISTEN FOR:

"probably not". No two motors are exactly the same, so one side runs a bit faster. If it *spins on the spot* when you press F, that's different, and the wheels test in Stage B would have caught it.

CHAPTER 12 • If it doesn't move

TABLE 12.1 If it doesn't move: symptom, test, cause and fix, circuit causes first

SYMPTOM	TEST MOST LIKELY CAUSE	FIX
ON light lit, no port on the laptop	A Charge-only USB cable; clone needs the CH340 driver	Another cable; install the driver (Chapter 6)

SYMPTOM	TEST	MOST LIKELY CAUSE	FIX
L light blinks slowly forever, monitor empty	A	The sketch never uploaded	Upload again; wait for "Done uploading"
L light on, but no <code>Car</code> <code>ready</code> even after RESET	A	Nothing is proved: the L light can be on for other reasons	Upload again (A3)
Strange symbols in the Serial Monitor	A	Serial Monitor not at 9600	Choose 9600; press RESET
Upload error ("not in sync", "port busy")	A	Wrong board or port; another program using the port	Tools → Board: Arduino Uno; pick the right port; replug
A locked school or work laptop won't install the IDE	(prep)	No permission to install software	Use a laptop you're allowed to install on (Chapter 1)
No light anywhere when you switch on	B	Cells backwards or not seated; battery lead loose	Cells out (parent), check + marks; tug the leads
No horn on V, but <code>Got V from USB</code>	B	Buzzer wires	Check B21–B25
Motor driver's light on, board's ON light off (USB out)	B	The Vin or GND jumper is missing or loose	Check B37–B44; tug both jumpers
<code>Got F from USB</code> , but no wheel turns	B	Switch off; battery leads or jumpers loose; signal wires on wrong pins	Switch on; check B37–B44; check B29–B34
All four wheels turn backwards on F	B	Every motor is the other way round for this sketch (normal)	Swap red and black on all four; type F again
One side turns backwards; the car spins	B	That side's motors are the other way round	Swap that side's red and black (both motors); type F again
One wheel fights the other on its side	B	That one motor's wires are the other way round	Swap red and black on the one turning backwards; type F again
F is right, but L turns right	B	The left motors are on OUT3/OUT4, the right ones on OUT1/OUT2	Move the left motors to OUT1/OUT2 and the right to OUT3/OUT4; type F again (expect all four backwards, then the row above)
Every speed the same	B	Cap still on ENA or ENB; speed wire on a pin without <code>~</code>	Check B18–B19 (caps), B29–B30 (pins 5, 6)
Wheels twitch and stop; monitor shows <code>(newline)</code>	B	Line ending isn't "No line ending"	Choose No Line Ending

SYMPTOM	TEST	MOST LIKELY CAUSE	FIX
ON light goes out when the USB cable comes out	B	The jumper from +12V to Vin, or from GND to GND, is missing or loose	Redo B37–B44
Motors hum but don't turn on the floor	B / D	Speed too low for the floor, or tired cells	Try speed 9; charge the cells
Module light off	C1	Module VCC or GND not in its column; board's 5V/GND jumpers out	Check C5, C6, B21, B22
ON light dims or goes out when you switch on with the module	C1	A short: 5V joined to GND	Switch off at once; find the wire in the wrong column
HM-10: "no devices found" (Android)	C2	Location off, or Chrome lacks Nearby devices	Location on; allow Nearby devices for Chrome
HM-10: nothing happens on Connect (iPhone)	C2	You're in Safari	Open the remote in Bluefy
HM-10: the remote can't find it after pairing in Settings	C2	The phone is holding the module	Settings → the module → Forget
HC-06: never appears in the scan	C2	No power, or connected to another phone	Check C1; turn off the other phone's Bluetooth
HC-06: PIN refused	C2	The module's code isn't 1234	Try 0000
Connected, but no <code>Got F</code> from phone	D	TXD not on pin 2; TXD and RXD swapped	Check C7, C8
HM-10: each press shows <code>Got (code ...)</code> , never <code>Got F</code>	D	The module talks at 115200 (some newer HM-10 software)	Set <code>BT_BAUD</code> to 115200 and upload (Chapter 11)
<code>Got F from phone</code> , but no <code>Car heard</code>	D	The 1 kΩ, the pin 3 wire or the RXD wire	Check C2, C4, C8 against the Chapter 10 figure. (The 2 kΩ can't show up in any test: C9 checks it by eye)
HC-06: the car jerks and stops after each letter	D	The app sends a newline	Settings → Send → Newline: None
Beeping won't stop	D	It's the reversing beep, or the horn	Send S
The car ignores you while the tune plays	D	<i>Happy Birthday</i> blocks everything for about 16 s, then repeats	Wait for the end, then send S. Stop before X next time
It stops and restarts when it starts moving	power	Tired cells (the board's power dips)	Charge the cells

CHAPTER 23 • Worked examples: spins on the spot, and connected but still

THE FAULT SKELETON: PRINT IT AND FILL IT IN BESIDE THE CAR

TABLE 23.1 The fault skeleton. One row per step of the loop

STEP	THE QUESTION IT ASKS
Look	What exactly happens? What changed since it last worked?
Which box?	Which stage test fails? Which boxes are cleared?
Split	Which one test cuts the remaining suspects in half? What did it show?
Suspects	What could cause exactly this? Cheapest to check first
Change one thing	What single change, with the power off if it's a wire?
Test again	Which test, and what result means it's fixed?
Say what you found	One sentence: the fault, and how you knew