Robot Adventskalender 2021

Elektronik-Labor Literatur Projekte Lernpakete Kalender

http://www.elektronik-labor.de/Lernpakete/Kalender21/Roboter21.htm

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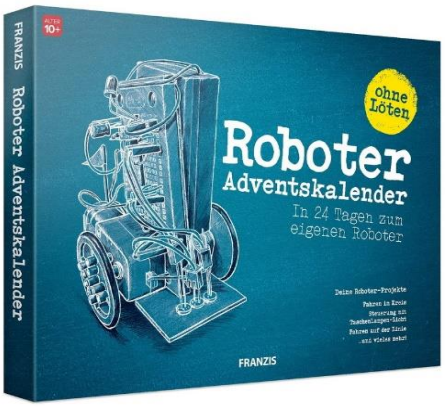


www.amazon.de/FRANZIS-67161-Roboter-Adventskalender-fahrbaren-technikbegeisterte/dp/B095C349SJ

A quick note by Juergen Pintaske:
I saw this kit, loved the idea.
Even if you want to write programs on the microbit or the Arduino, this kit of parts gives you all of the components to extend to systems with more capabilities; but shows already how much can be done without any microcontroller in these 24 experiments. One experiment for each day of the 24 days before Christmas.

And the components can be used with Burkhard's Sparrow and TPS / Myco as well ...

The 24 Days:

3	Day 1	**Motor and Gearbox**	Motor 1	
4	Day 2	**Stable Connections**	Battery compartment with switch –	Breadboard
6	Day 3	**At the Push of a Button**	Wire and push button	
7	Day 4	**Flashing red Light**	LED red flashing,	-1k Resistor
8	Day 5	**Electric Lighting**	LED white	
9	Day 6	**2 Motors working together**	Motor 2	
10	Day 7	**Amplified Current**	Transistor BC337	
12	Day 8	**Switched on with Light**	Phototransistor	
13	Day 9	**Light switches Light**	470 Ω Resistor	
14	Day 10	**Light turns on the Motor**	2 double Cables	
15	Day 11	**Reduced Speed**	Transistor BC337	
16	Day 12	**Light turns the Motor off**	10 kΩ Resistor	
17	Day 13	**Right or Left**	Transistor BC337	
18	Day 14	**Right-left Light Control**	Phototransistor	
18	Day 15	**Assembly Work**	Bolt and Nut	
20	Day 16	**On your own Wheels**	2 Wheels, thick Wire	
22	Day 17	**Driving in a Circle**	Transistor BC337	
23	Day 18	**Change the Radius**	Transistor BC337	
23	Day 19	**Guided Direction**	10 kΩ Resistor	
25	Day 20	**A waddling Walk**	100 µF Capacitor	
26	Day 21	**Two-channel Light Control**	2 double Cables	
27	Day 22	**Following the black Line**	Sensor Plate for Line Follower	
29	Day 23	**More Light**	Resistance 330 Ω	
30	Day 24	**Driving Routes**	Resistance 680 Ω	

Components:

Motor 1	- Breadboard	- Battery Compartment	- Push Button
Wire	- Flash LED red	- 1k	- LED White
Motor 2	- BC337	- BC337	- Photo Transistor
470R	- 2 Cables	- BC337	- 10k
BC337	- Phototransistor	- Bolt and Nut	- 2 Wheels
Thick Wire	- BC337	- 10k	- 100uF
2 Cables	- Sensor Plate	- 330R	- 680R

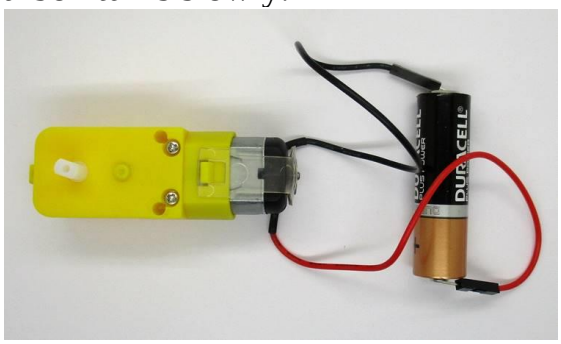
Preface

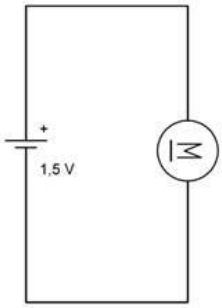
In our technological world, robots are becoming more and more important. Most robots look very different from what you once imagined. But in many areas of the industry they are already doing a large part of the work. And in the future, there will be more and more, and they will also be found in our private sphere.
So, it makes a lot of sense to have a playful look at building simple robots. The result will be far behind that of today's industrial robots, but some basic principles of robot control will become clear, and potential problems and dangers are also recognized. In addition, your own creative engagement with technology is always beneficial, because the new experience and knowledge can also be useful in completely different areas.

We wish you a lot of fun and success!

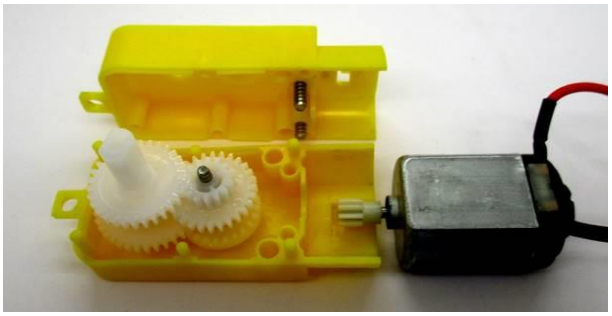
1 - Motor and Gearbox

A geared motor appears behind the first door of the calendar. In the following experiments, three AA cells with 1.5 V each, which are not included in the calendar, are required for operation. A single cell is sufficient for an initial test. If you hold the connection cables of the motor to both poles of the battery, it starts to run. You can hear a buzz and the axis of the gearbox turns slowly.





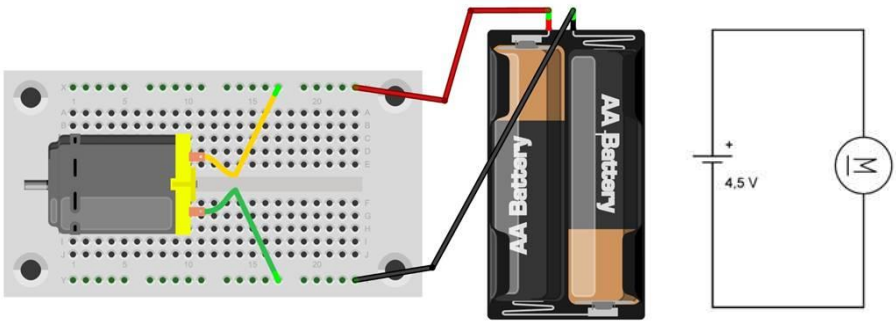
As with any DC motor, you can change the direction of rotation by reversing the battery poles. And you can make the engine run faster by increasing the voltage. With two cells connected in series and a total of 3 V, the motor runs about twice as fast.



You would have to open the housing to look into the gearbox ***(please do not do this).*** A total of four gears ensure a strong reduction of speed. A bolted-on wheel therefore turns much slower than the motor axis - and at the same time with a multiple of the initial torque. It is therefore hardly possible to stop the gear shaft with bare fingers while the engine is running.

2 - Stable Connections Breadboard, battery compartment with switch

The second compartment provides a battery box with connection cables and switch, as well as a plug-in board. The breadboard has two horizontal contact strips X and Y, to which the positive pole (red) and the negative pole (black) of the battery compartment are to be connected. In addition, there are 46 vertical strips, each with five contacts, which even facilitate the construction of larger circuits. The motor should now be connected to any 2 contacts on the supply rails X and Y.

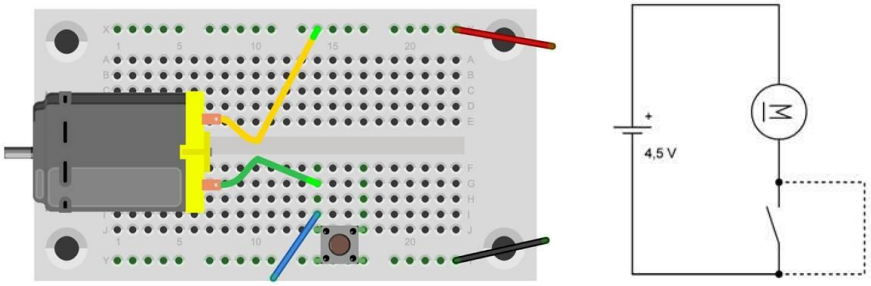


The layout shows an open battery compartment with two AA cells, in which the internal connections are also visible. The battery compartment actually used in this project here is closed and contains three cells and an additional switch. The marking of the poles is crucial. The red wire is the positive pole, the black wire is the negative pole. In all of the following assembly drawings, only the connection cables are shown.
The engine is always shown without a gearbox in the drawings. But that doesn't mean that you should separate it from the gearbox. In the real setup, you always use the motor on the gearbox as supplied.

After inserting the three battery cells, the switch can be operated. When it is switched on, the motor runs quickly and powerfully. The direction of rotation can be changed by swapping the 2 motor cables. Before every change and after every test, the switch on the battery compartment should be pushed to the OFF position. By switching off the battery you prevent accidental short circuits and unnecessary battery capacity usage.

3 - At the Push of a Button Push button switch + wire

Red wire and a pushbutton switch appear behind door number 3. The button has four connections, two of which are conductively connected in the longitudinal direction (imagine a flat wire going from one end to the other). Inside there is a bent piece metal that connects both sides (top and bottom row) when it pushes down on to the contacts with enough pressure. The motor can now be started and stopped with the button.



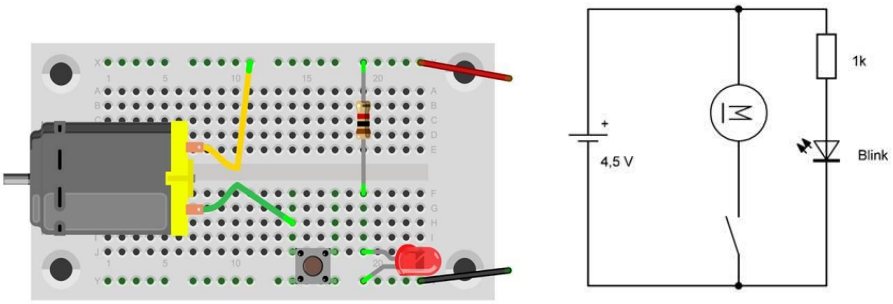
The motor can also be switched to tun continuously with a wire (dotted connection in parallel to the button). To do this, a piece of wire 3 cm in length is to be cut off and the insulation at both ends removed for a length of about 5 mm. Only one end is tucked in in the assembly drawing. But if you connect the free end to the negative line with the black wire (Y), the pushbutton switch is bridged (as if it is permanently pushed / closed).

4 - Flashing red Light Red flashing LED + Resistor 1 k

Today, the calendar provides a red LED and a resistor with one kiloohm (1 kΩ, brown, black, red). When you switch it on for the first time, you can see that it is a special LED, an automaticly flashing LED. LEDs have connecting wires of different lengths. The shorter wire is the negative pole (cathode), the longer is the positive pole (anode). In addition, the negative pole has a flattened side on the lower collar of the plastic housing.

Attention: an LED basically needs a series resistor, which ensures that the permitted current is not exceeded. This also applies to this blinking LED. The resistance determines the current and brightness with which the LED is operated. A direct connection without resistance might destroy the LED. The LED can withstand currents of up to 20 milliamperes (20 mA). With a resistance of 1 kΩ in series, a current of less than 3 mA will flow.

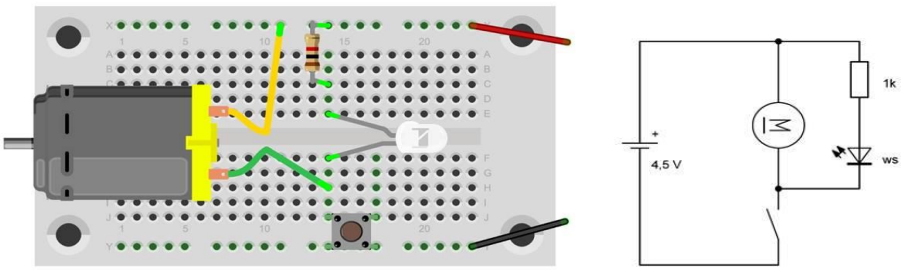
When the battery is switched on, the red LED flashes. Almost every industrial robot and every autonomous vehicle has such a hazard warning light. This is very important to prevent accidents. That is why the blinking LED is introduced here on our way to a functioning robot.



The motor will only run when you press the pushbutton. In most cases, however, the flashing LED stops immediately. That is caused by disturbances that the motor generates. Short pulses on the operating voltage disrupt the function of the flashing LED. A method that prevents these disturbances will be shown later.

5 - Electric Lighting LED white

The white LED from the fifth compartment is now used in place of the flashing LED. It later serves as a spotlight so that the robot can see where it is moving. The existing 1 kΩ resistor ensures medium brightness.



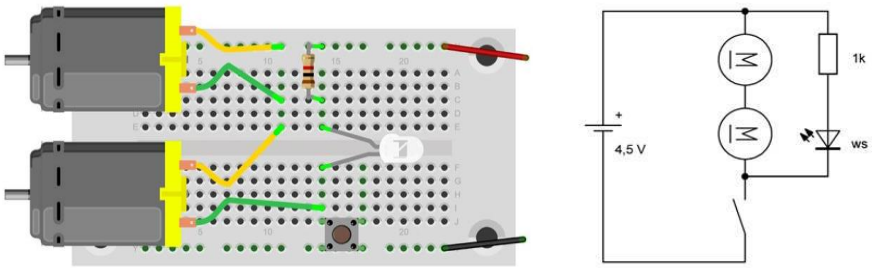
A small additional experiment shows, that the motor also works as a generator. To do this, switch off the battery and turn the gear shaft. This requires a lot of force because of the large translation. Nothing happens in one direction of rotation, in the other direction the LED starts to light up. The LED only lights up if the polarity of the voltage is correct. The engine thus produces electrical energy as a generator. This property of a motor is often used for energy recovery when braking.

6 - 2 Motors working together The second Motor

A second motor can be found in compartment no. 6. It should be connected in series with the first motor. Both motors now run at half voltage and half speed. However, if you slow down one of the motors, the other will go faster.

With this series connection, the same current flows through both motors. Therefore, both will deliver the same torque. It is comparable to the differential gear of a car. Both driven wheels receive the same torque and thus bring the same power to the road, but the speed of rotation can be different, which makes it possible to go around corners. In the case of electric motors, both have the same voltage at the same speed. Each receives half of the

battery voltage of around 4.5 V, i.e. around 2.25 V. However, if a motor is braked with the fingers, its working voltage drops. The other motor will then receive more voltage and rotates correspondingly faster.



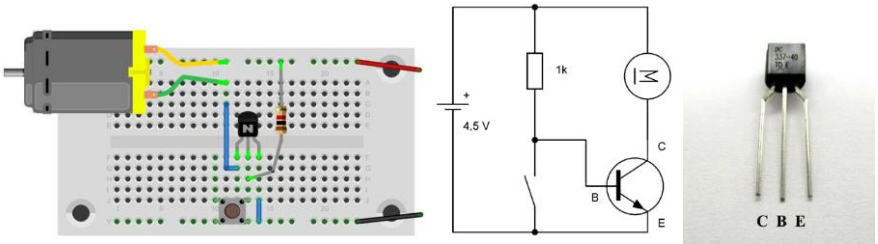
The motors use a current of around 100 mA when idling. If you brake it, the speed drops and the power consumption increases with the greater torque. The battery voltage remains almost unchanged as long as the batteries are fresh. With heavily used batteries, however, the voltage will drop with a heavy load, which can be seen with the change in the LED brightness.
If one motor is stopped completely, the other motor will run at full speed. If you then let go of the braked axis, the stationary motor usually no longer starts by itself. But you can also slow down the other motor strongly. Then the current through the motors increases so that the first motor starts up again. Another method is to briefly release the pushbutton and then press it again. This will start both engines. At the first moment a larger current flows, which then decreases with increasing speed.

7 - Amplified Current

Transistor BC337

The compartment number 7 brings a component with three connections, a transistor of the type BC337. A transistor is a component used to amplify current. It has three connections: from right to left there are the emitter (E), the base (B) and the collector (C). The connections must not be mixed up. The emitter is connected to minus. A small current flows through the base and the increased current then through the collector to the emitter.

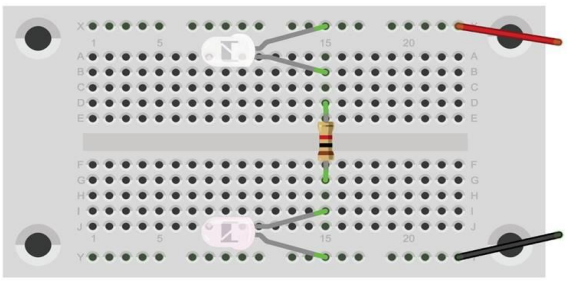
When the battery is switched on, the motor runs. If you press the button, it stops as you shorten any current into the base of the transistor. If you let go of the button, but pull out the resistance, the motor also stops. Only a small current of around 4 mA flows through the resistor. When this small current flows through the base of the transistor, it turns on a much larger collector current that flows through the motor. When the push button is closed, current still flows through the resistor, but no longer through the base. The collector current is then switched off.

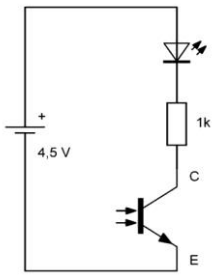


The transistor BC337 used is well suited for this task, because it has a large current gain factor and can withstand a relatively large amount of current. The data sheet reveals the most important data: Maximum collector voltage: 45 V, maximum collector current 800 mA, maximum power loss: 625 mW, minimum current amplification factor: 250.

8 - Switched on with Light Phototransistor

A phototransistor is waiting behind the eighth door. At first glance, the component looks like a white LED. But if you look closely from the front, you can see a small dark rectangle. This is the light-sensitive area. A phototransistor only has two connections: the collector (short wire) and the emitter (long wire). There is also a base, but it has no connection to the outside world. The base current is created by the ambient light.

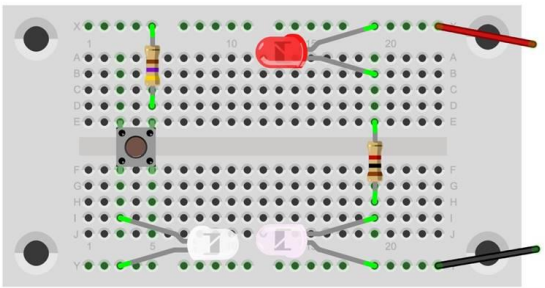


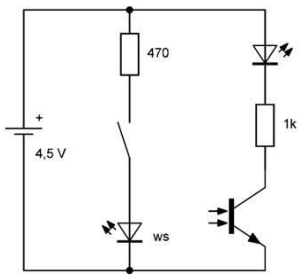


When installing the phototransistor, the longer wire is on the negative pole, which is very different from an LED. The collector current flows through the resistor and through the white LED. When enough light shines on the phototransistor, the LED is switched on. In low light it shines correspondingly weaker. This also works in low light. The circuit therefore works like a light amplifier; the white LED is always several times brighter than the ambient light.

9 - Light switches Light Resistance 470 Ω

A resistor with 470 ohms (470 Ω, yellow, purple, brown) can be found in the ninth compartment. This means that two independent circuit blocks can be set up now, one with the white LED on the left, and one with the red flashing LED and the phototransistor. If you now press the pushbutton switch, the white LED lights up. And at the same time the red LED starts to flash. To do this, however, the white LED and the phototransistor have to be bent so that the white LED shines directly into the phototransistor.



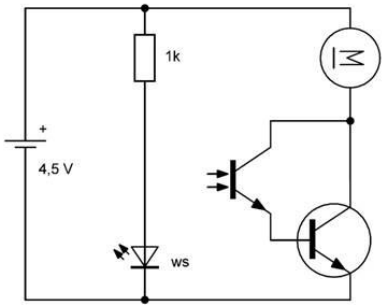


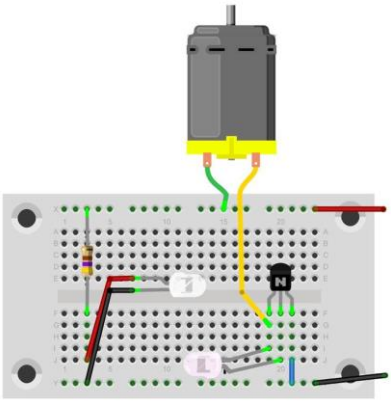
It is easy to prove that the blinking LED is actually switched on by light by inserting a black sheet of paper between the white LED and the phototransistor. This shades the light and thus prevents the flow of current through the phototransistor.

10 - Light turns on the Motor

2 double cables

Today, the calendar delivers two double cables with plugs and sockets. They can be used to flexibly extend the LED connections. The white LED from the last setup is now equipped with a cable so that you can point the small LED headlight here and there into any direction. This time, a motor will be controlled via light. The phototransistor only supplies small currents that are just sufficient to operate an LED. But with an additional transistor as an amplifier, it is also sufficient to drive the motor. It remains in the idle state and runs when the phototransistor is illuminated directly via the white LED.





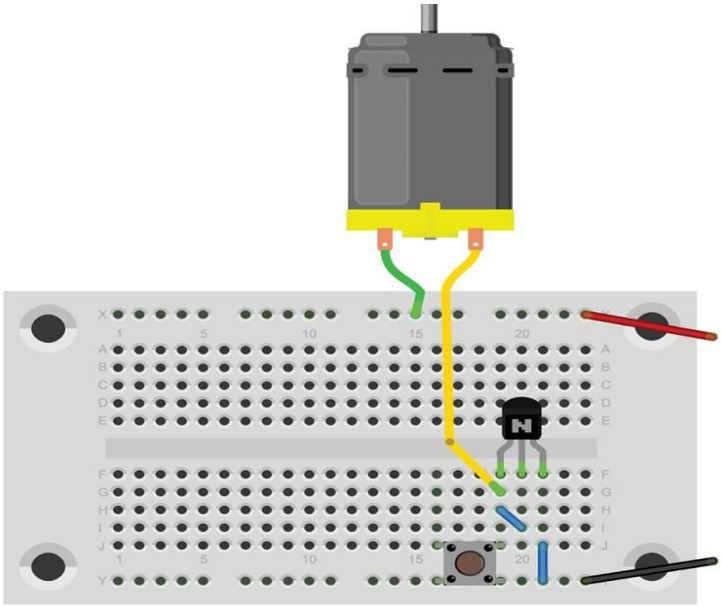
If the light is directed a little to the side, the speed can be reduced. If the ambient light is sufficiently bright, the motor can also be controlled by hand by shading the phototransistor.

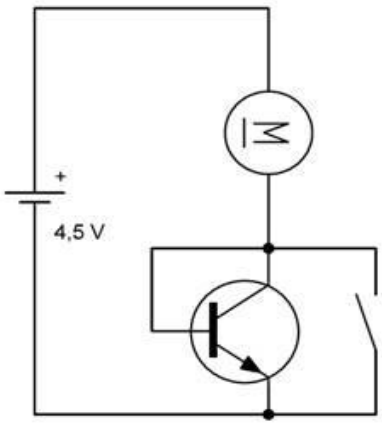
11 - Reduced Speed

Transistor BC337

Another BC337 transistor appears behind door no 11. As the last experiment showed, a transistor can not only switch the motor on completely, but also let it run at a reduced speed. Today, the engine should run with only a slightly reduced voltage. If you press the switch, it runs at full speed again. The difference can be heard clearly.

With a direct connection between base and collector, the transistor causes a voltage drop of around 0.8 V. This reduces the motor voltage by around 20%. When the switch is closed there is a direct connection and the motor is back to full voltage.



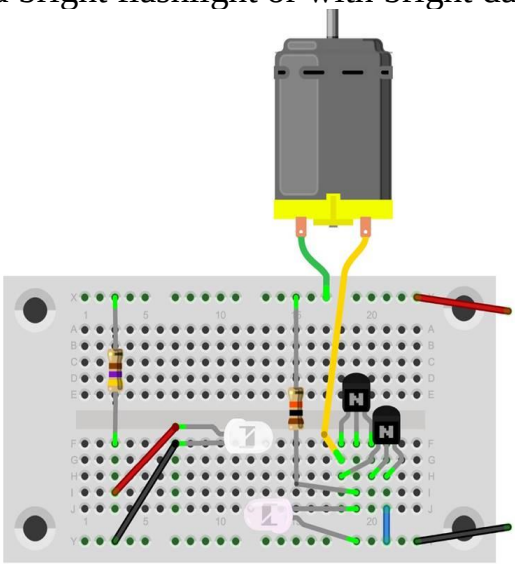


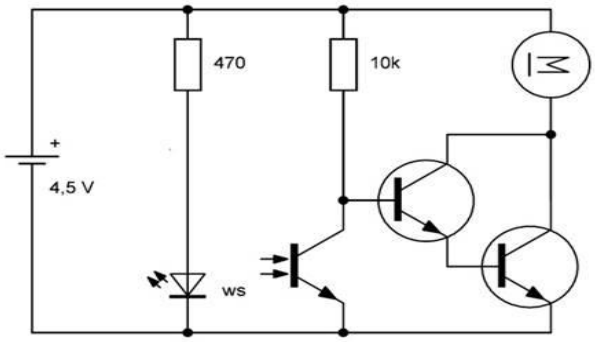
Since there are now two transistors, you can set up the same circuit twice and let the two motors run slower. The second pushbutton can be implemented via the piece of wire used before.

12 - Light turns the Motor off

Resistance 10 kΩ

Compartment number 12 hides a 10 kΩ resistor (brown, black, orange). It is used for a circuit where the motor runs normally, but stops when there is light. This time two transistors are used for even more amplification. Only a small current flows through the resistor, which is amplified enough to switch on the motor. However, if enough light falls on the phototransistor, the control current from the 10k resistor is diverted, so that no more base current flows and the transistors switch off the motor.
The experiment can be carried out with the LED spotlight on the circuit board, but also with a bright flashlight or with bright daylight.

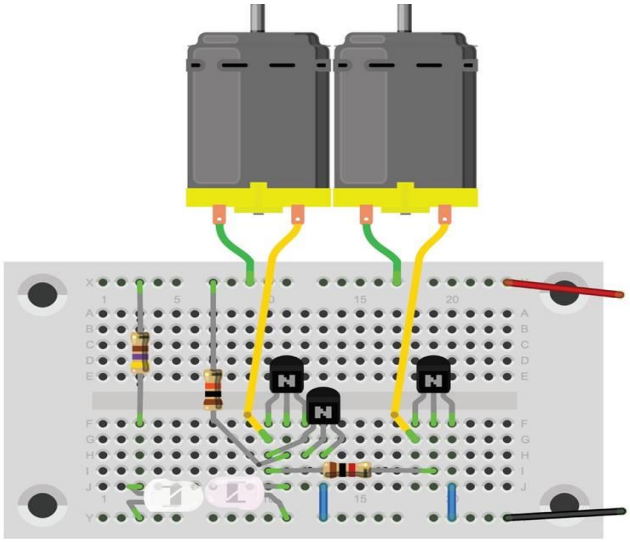


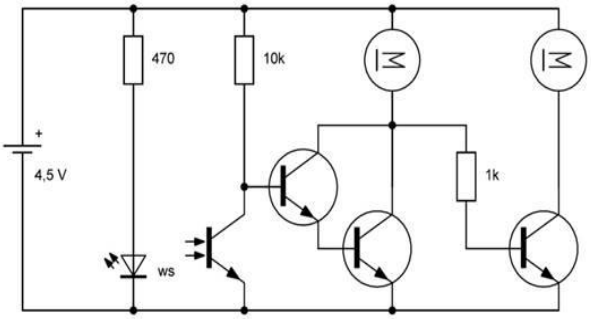


When the brightness is high enough, the engine stops and can be started again via the shadow of the hand.

13 - Right or Left Transistor BC337

A third BC337 transistor appears in the thirteenth compartment. It is now used for a further switching stage that controls the second motor. Whenever the left motor is running, the right motor should stand still, and vice versa. The entire experiment can again be controlled with the light source, either with the LED which is movable on the cable or by shading.
On switches to off, and off changes into on; such a circuit is called an inverter. The base current for the right transistor is derived from the collector of the left transistor. Whenever the left motor is switched on, the collector voltage is low, so that no or very little current flows to the base of the right transistor.

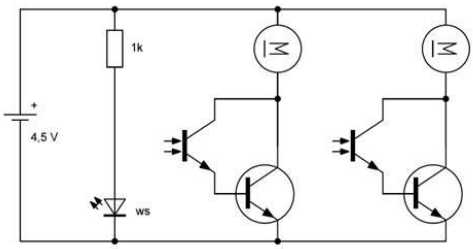


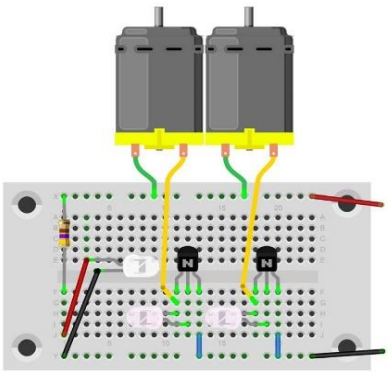


If, on the other hand, the left motor is switched off, the voltage across the base resistor is high, so that the right transistor becomes conductive.

14 - Right-left Light Control Phototransistor

A second phototransistor can be found in compartment number 14. This means that both motors can now be controlled with light - independent of each other. Whenever one of the phototransistors receives enough light, the associated motor is switched on.



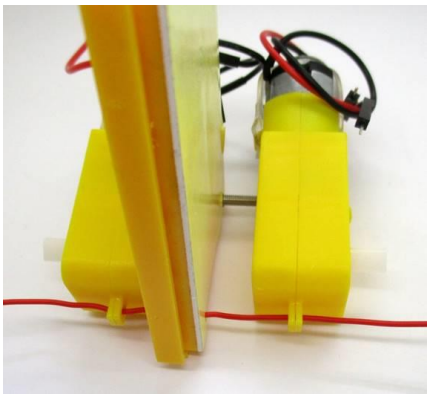


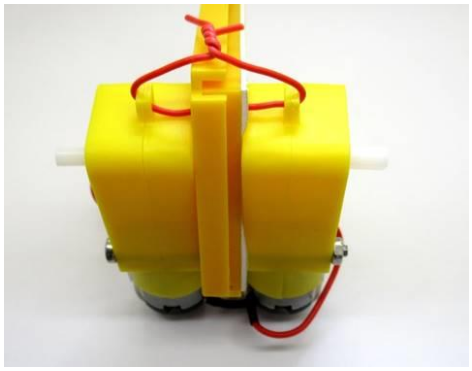
The LED on the cable or an external lamp can be used for control. With a suitable light source, both sensors can be illuminated at the same time, so that both motors run at the same time.

15 - Assembly Work

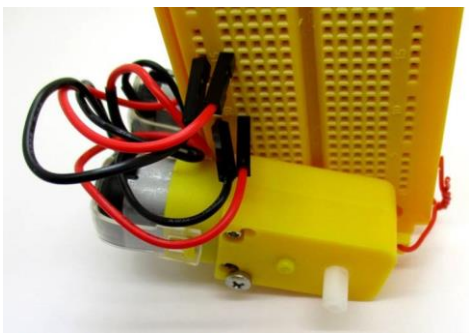
Bolt and Nut

So far, there have only been dry exercises for electronics. But now the construction of a complete little robot begins. This requires a 50 mm long screw with an M3 nut, which can be found in today's calendar compartment.
A long screw through the hole at the level of the X-rail and close to the row of holes A should then hold both motors together. To do this, the rear protective film of the breadboard must be pierced. You put the screw through both gear blocks and the breadboard. If the motors are then turned a little diagonally, the fastening straps on the wheel side are nearly exactly above the second fastening hole next to the Y-rail. In this position they should be fixed with some wire or a cable tie.





If both motors are parallel, the screw can be tightened until the protective film of the breadboard is visibly compressed. At the end, a wire is tied together via both gear straps and stretched so far, that the motors are sufficiently tight over the entire surface.

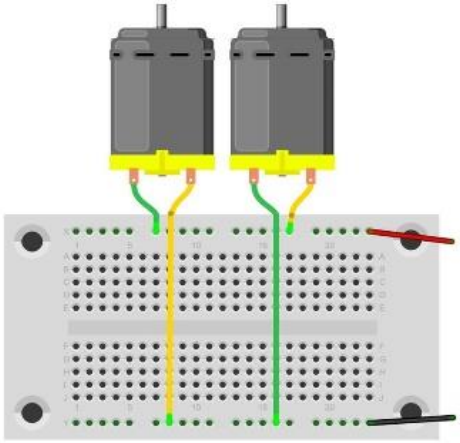


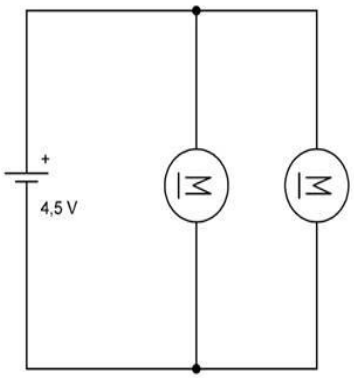
Finally, the battery compartment must be attached to the back of the breadboard. It should lie parallel on the motor, while the breadboard is a bit inclined to it. A rubber band or tied wire is used to hold the battery compartment to the breadboard.
When the robot is then upright, the circuit board tilts slightly backwards in the later driving wind. The robot approaches its later appearance: compact, powerful and dynamic.

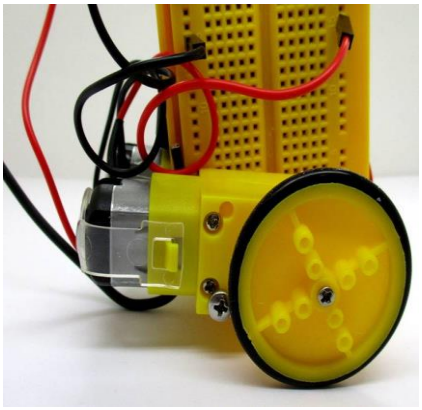
16 - On your own Wheels

Wheels, thick Wire

In compartment number 16 you will find the wheels, tires and fastening screws and also a thick copper wire with insulation. First the tires have to be placed on the rims. Then the wheels are placed on the axles in such a way that they can no longer turn. And in the end the screws are inserted, but not overtightened. Attention, if the wheel bolts are tightened too much, the bolts will spin and hold less.







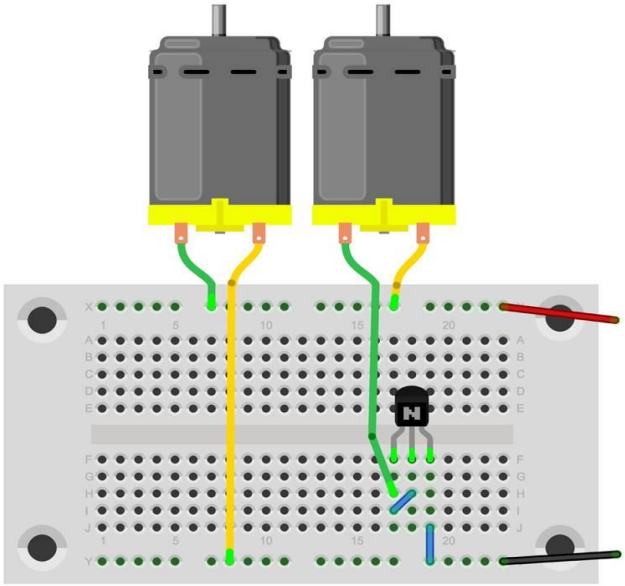
When the robot is now on its wheels, the motors are touching the ground. But they should stand a little higher, for which purpose two more wheels are used in most vehicles. But it is also possible with just one wheel or, even more simply, with a small runner, which then drags over the ground with as little friction as possible. Such a runner should now be formed from the thick wire. The wire is clamped at the edge between the breadboard and the motor. To do this, you can loosen the fastening screw of the motors once and then tighten it again at the end. When the wire is jammed in, it should be shaped into an arch that rests on the ground so that the motors are parallel to the ground.

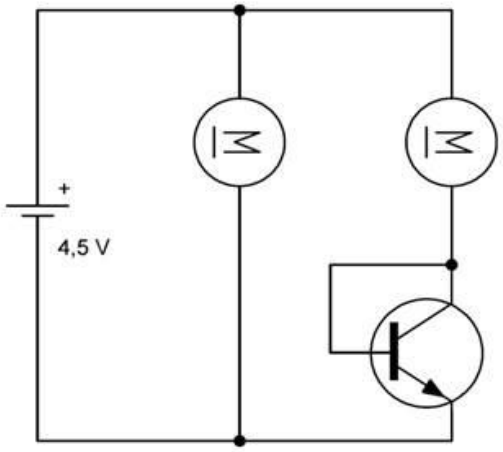
Now comes the first test: the robot should simply drive straight ahead. Both motors are therefore connected in parallel. So that both wheels turn in the same direction, the cables must be plugged in differently. If the robot moves backwards, the connections have to be swapped again. Because the two motors usually do not run at exactly the same speed, the robot will not drive just straight ahead but in a large curve.

17 - Driving in a Circle

Transistor BC337

Another BC337 transistor comes into play today. This transistor is used to make one of the two motors run a little slower. The circuit is already known: the base and collector are short-circuited and a voltage drop of around 0.8 V is achieved. If one motor runs a little slower than the other, the robot moves in an exact circle.



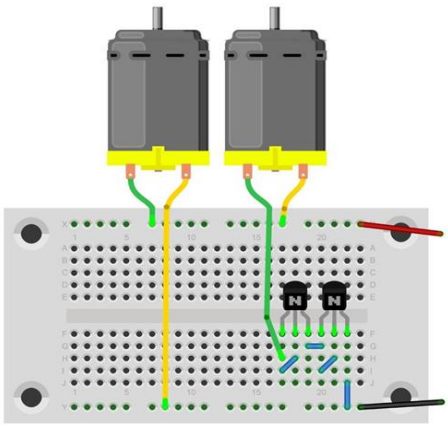


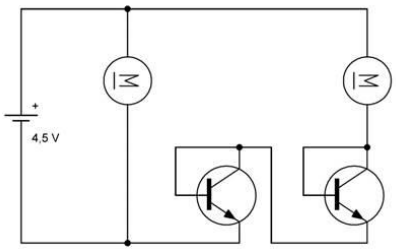
The circle has a diameter of approx. 1 m. Whether you drive clockwise or the other way around depends on which motor is running slower. You can put a bottle or a vase exactly in the center of the circular path. The uninitiated observer may then think that a higher intelligence is at work here, which either permanently measures the radius or carries out complicated path calculations. Not everyone needs to know that it's so easy.

18 - Change the Radius

Transistor BC337

The fourth transistor appears behind the door no 18. Relatively complex tasks can be solved with this now. But today only the circle radius should be reduced. To do this, it is sufficient to connect a second transistor in series with the first. Now the voltage drop is around 1.6 V. The circle radius is now well below 50 cm.





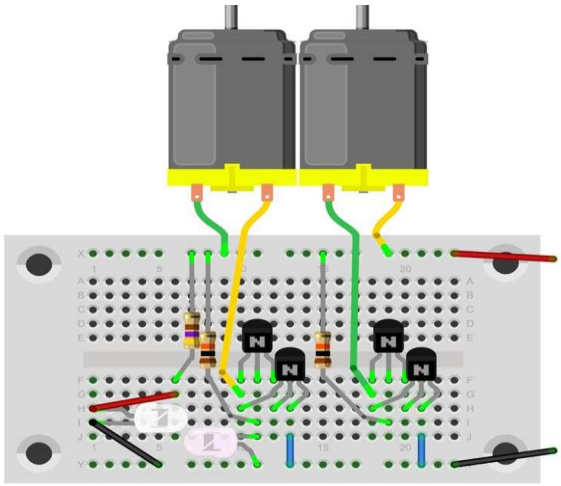
19 - Guided Direction

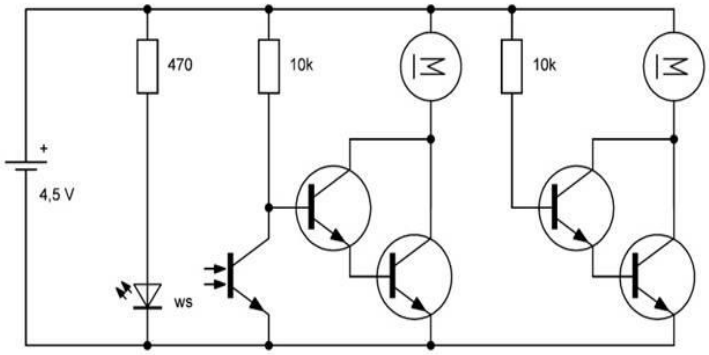
Resistance 10 kΩ

Compartment no. 19 brings another resistor with 10 kΩ (brown, black, orange) to light. This means that two similar amplifier stages can now be set up, so that the robot drives straight

ahead in its basic state. However, one side is connected to a phototransistor which can be used to stop the motor. A tight curve is therefore driven when there is lighting.

The first test can still be carried out with the white LED on the cable. This can also be used to test whether the robot turns left or right when it is illuminated. To change the direction, you can simply plug the phototransistor to control the other transistors. In real use on the ground, the robot can be controlled with a flashlight. Whenever the phototransistor is hit with light, the robot changes direction. With a little skill, any place in the room can now be reached. However, the room may need to be darkened a little.



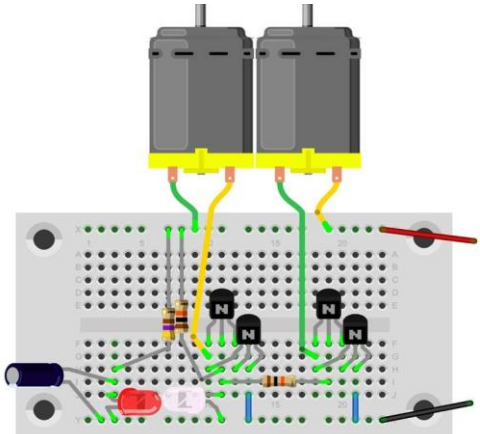


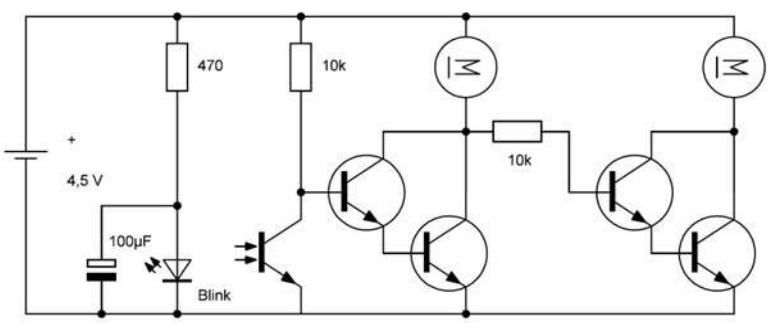
If you want to automate the control even further, you can set up several lamps in the room to let the robot drive a defined distance. Whenever it comes into the area of a lamp, it changes direction until the phototransistor has moved out of the light. With a lot of skill, you could even achieve that the robot drives several times through the same course.

20 – A waddling Walk

100 µF Capacitor

An electrolytic capacitor with 100 µF can be found in compartment no. 20. It is needed today to operate the red flashing LED together with the motors. The motors generate impulse interference that can interfere with the steady flashing of the LED. The capacitor smooths the LED voltage and ensures trouble-free operation. This is important because the blinking LED is now the central control of the robot, its brain, so to speak.

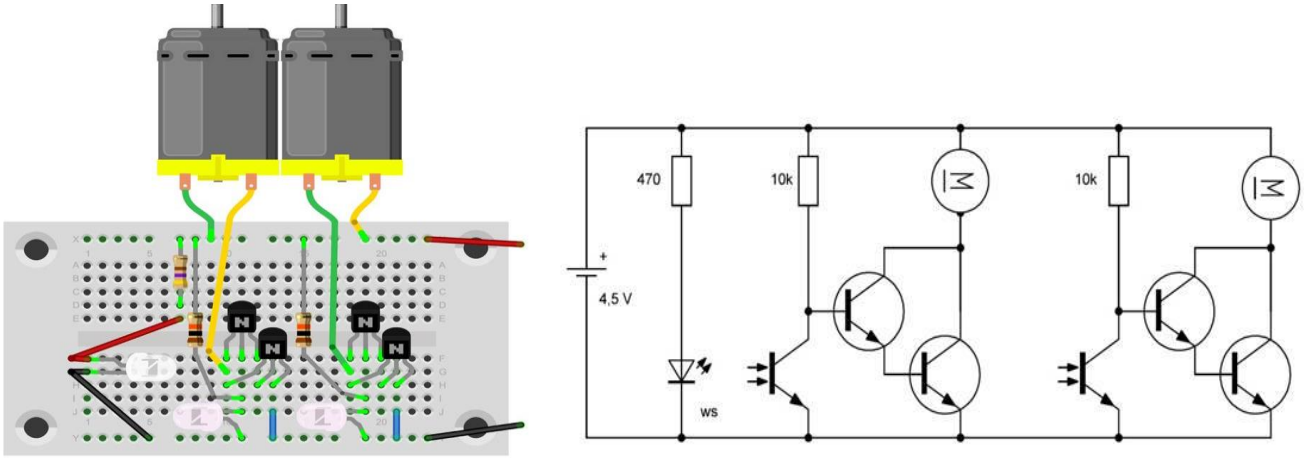




The LED illuminates a phototransistor, that switches off the left motor. Whenever the left motor is stopped, the right motor runs and vice versa. This gives the robot a waddling gait similar to that of a duck. It's still not a mentally high performance, but it looks impressive. The robot's brain is nowhere near as powerful as a duck's brain and cannot even come close to a sparrow's brain. There is still room to improve!

21 - Two-channel Light Control 2 double Cables

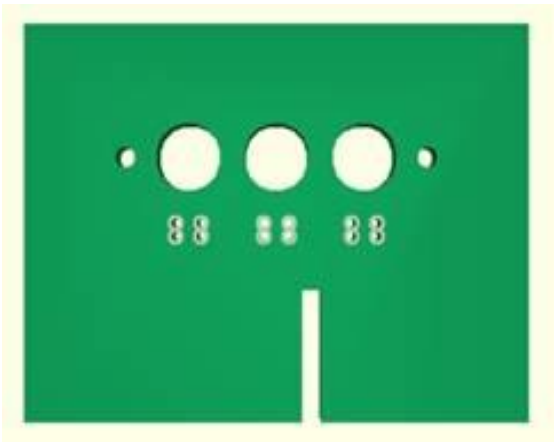
Two more double cables with plugs and sockets can be found in compartment no. 21. This means that both phototransistors can now be used on extended cables. This opens up new possibilities for control via light signals. The extension cables are not shown in the assembly drawings because, depending on the experiment, you can also work with directly plugged-in components.

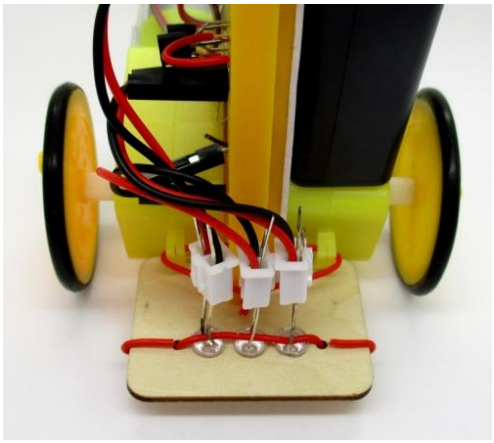


The robot is now controlled via two phototransistors, which can switch off a motor independent of each other. In the following example, they should follow a black line that is printed on the enclosed box. As a simplified preliminary experiment, direct control with a flashlight is suitable. You can specifically illuminate one of the phototransistors to change direction. Or you can illuminate both to stop the robot.
For this experiment, both phototransistors can either be plugged into the circuit board or at the end of the extension cable. The position can be changed so that control with a flashlight is possible either from above, from the side or from the front or back.

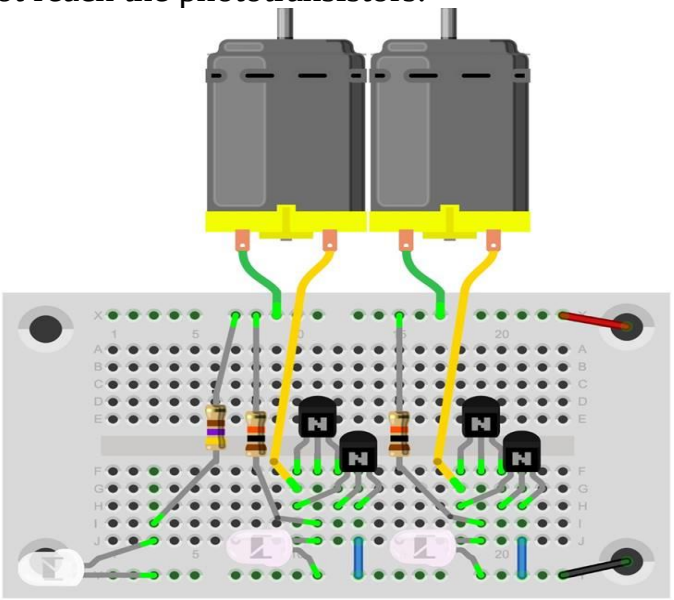
22 – Following the black Line Sensor plate

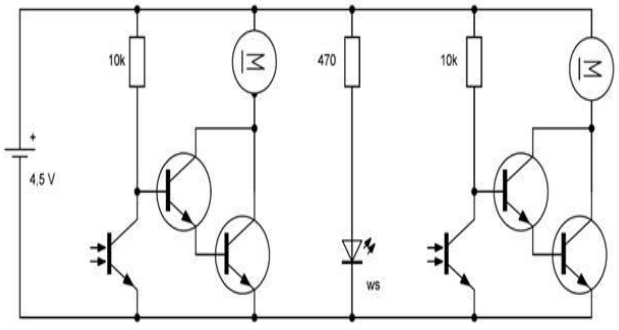
Today a small circuit board with three holes for the LED and the phototransistors appears behind the door. It has a suitable recess and should be placed from the front on the edge of the breadboard. The white LED must then be inserted into the middle hole, the phototransistors to the right and left of it. Both should look down at the front edge of the robot and steer it, so that it drives exactly on the black line on the white box.





All three components should be pressed in firmly. If necessary, they can be secured against slipping out with an additional wire, which is fed through the holes on the side. The circuit board contains additional contact points for alternative soldering of the connections, but these are normally not used. At the end, the extension cables are attached in such a way that the black wire comes to the minus, i.e. the short wire of the LED, and the long wires of the phototransistors to the red wire.
For optimal function, the LED and the phototransistors must float as close as possible (approx. 1 ... 3 mm) above the floor. To do this, you have to lean the robot a little forward by bending the runner at the rear end larger. The white LED creates a round light spot that is slightly smaller than the black line.
If the LED hovers in the middle above the black stripe, the light is swallowed up and does not reach the phototransistors.





But if there is a deviation, some light falls on the white surface and is scattered from there. The phototransistor on the corresponding side receives the light and switches off the motor on the opposite side, so that the direction is corrected. If the phototransistors are connected (wrongly) the other way around, the track is left completely.

If everything is set up and set correctly, the robot should be able to follow the black line on its own. The movements are jerky, and if the setting is not completely optimal or the ambient light is too bright, the robot can jump off the track. But then it stops automatically because both phototransistors receive light. So, it is impossible for the robot to take a wrong

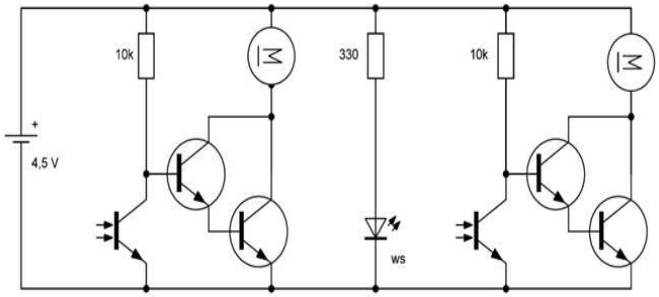
path. This behavior thus corresponds to Asimov's first robot law: A robot must never injure or endanger a person.

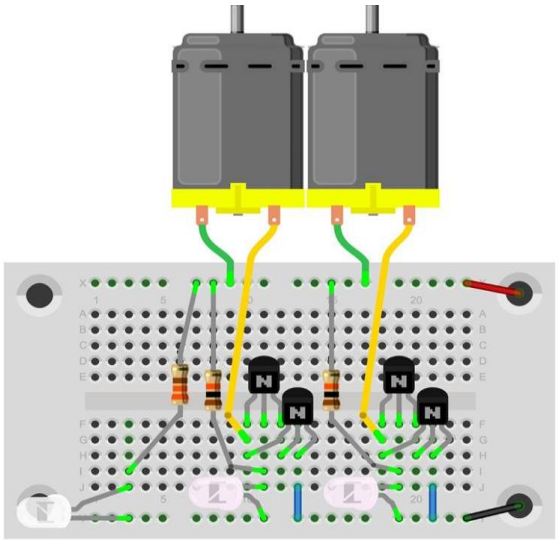
The assembly drawing does not show the sensors on their extension cables, but in the position where they are ultimately connected. Think of these connections being elongated, so that they fit into the holes in the sensor plate. And don't forget: the left phototransistor belongs to the right motor and vice versa.

23 - More Light Resistance 330 Ω

Today two flags and another resistance appear. The resistor has 330 Ω (orange, orange, brown) and can replace the previously used series resistor of 470 Ω for the white LED. This makes the LED a little brighter. You can test, which of the two resistors the control works more reliably with. That also depends on the brightness of the surroundings.

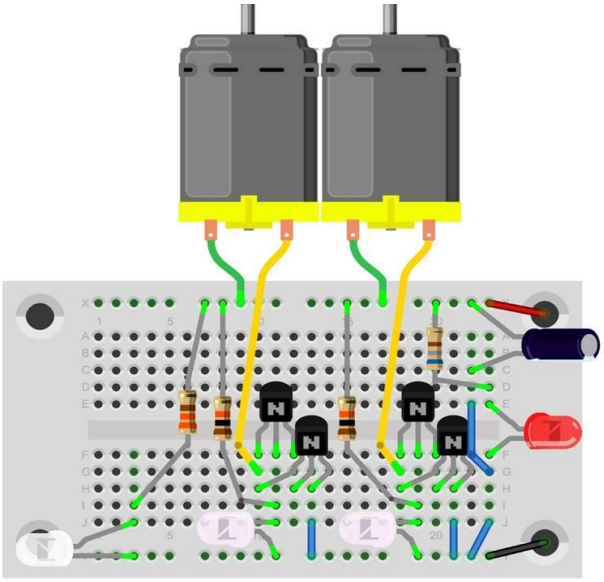
Now that almost everything is ready, the robot should show its colors! Therefore, one of the prepared flags is mounted on the protruding wire end of the thick skidding wire. You can either use the pre-printed flag or a self-painted flag. Glue or tape is suitable for fastening.

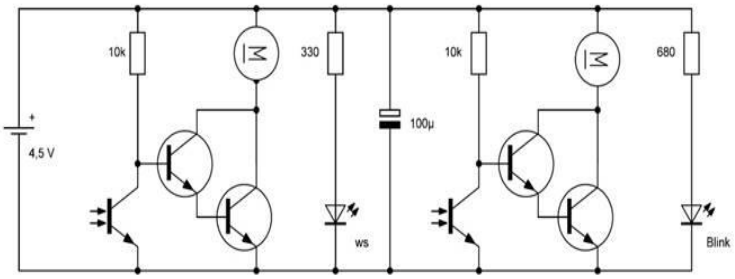




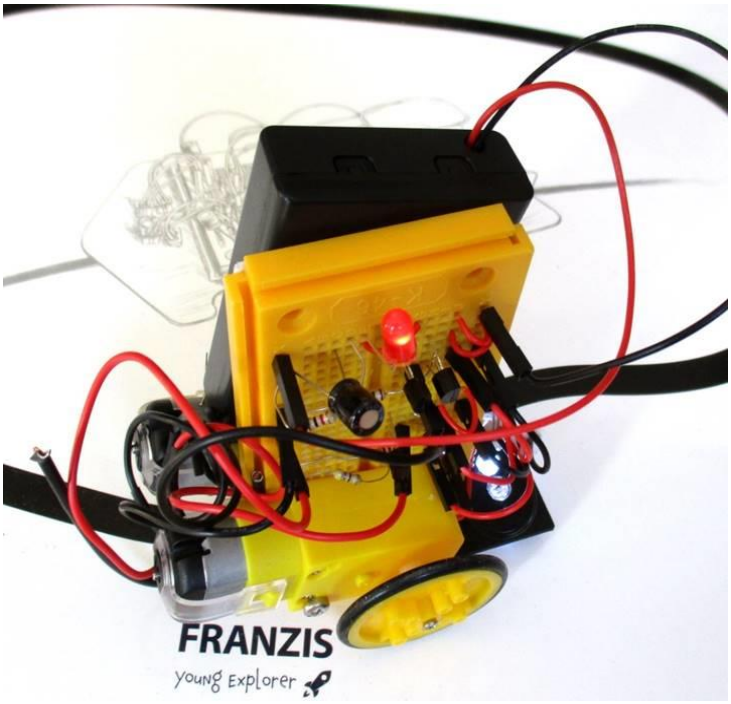
24 - Driving Routes Resistance 680 Ω

Behind the last door of the calendar you will find a small piece of paper **with a download link** for a longer route to print out yourself, and also a resistor with 680 Ω (blue, gray, brown). It can be used as a series resistor for the white LED to test another variant of the brightness setting, or alternatively as a series resistor for the red flashing LED. It is installed as the last change, so that the robot draws attention to itself during operation. This corresponds to the general robot traffic rules and should help avoid accidents.





This means that the robot can cover longer distances on the self-printed course or in the entire apartment. All you have to do is lay out a sheet of paper with a black line. Who knows, maybe our robot can then make itsef useful, and deliver short written messages or small gifts (diamond rings and the like).



The switch on the battery box is also very important. Everyone who shares their living space with a robot must be instructed about the use of the main switch, and must be able to switch off the robot at any time. Mothers should explain it to their sons and fathers to their daughters, so that one day the fears of our worst cinema films about robots taking over the world won't come true.

29 November 2021 – Juergen Pintaske, ExMark