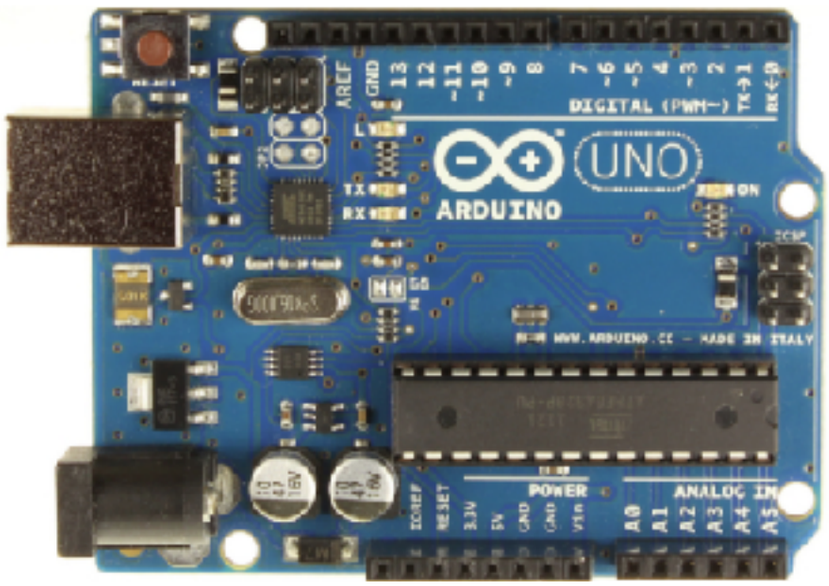
Programming and Sensors

Brad Miller
Associate Director, WPI Robotics Resource Center

System Components



Arduino

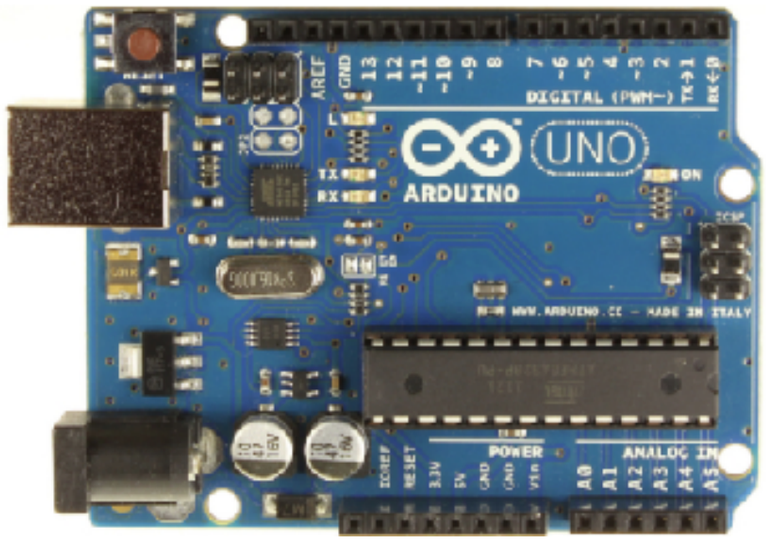
Actuators
(motors and servos)

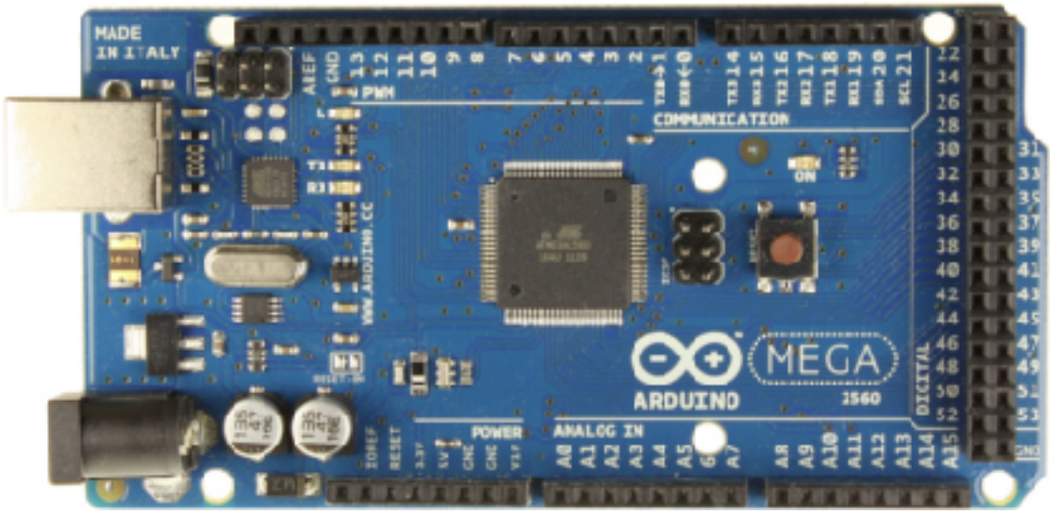
Sensors

Controller

Arduino

- Inexpensive and easy to use prototyping platform for electronics projects
- Programmed in C or C++
- Two models at WPI
  - Uno in student take-home kits
  - Mega in the lab kit

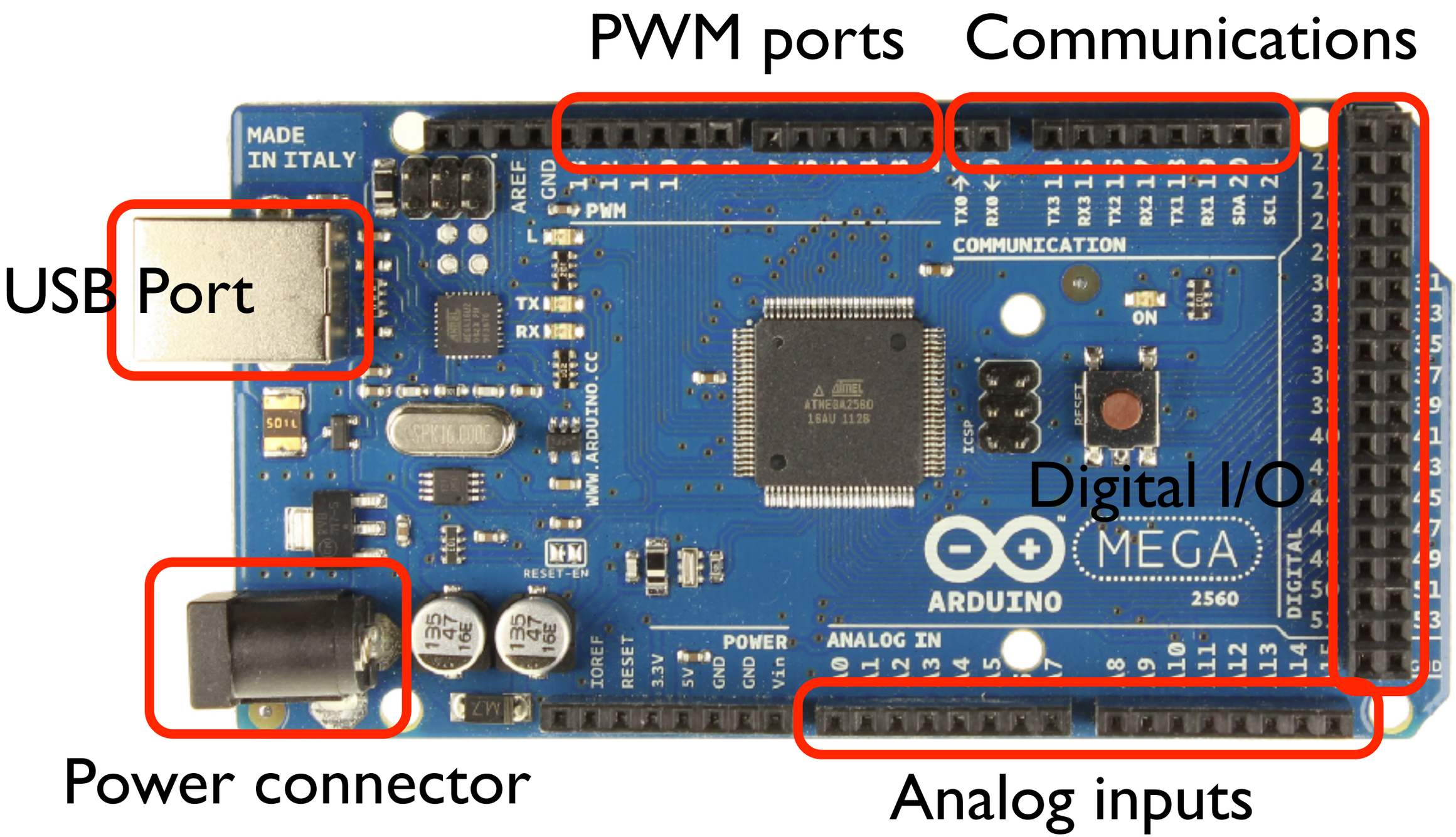




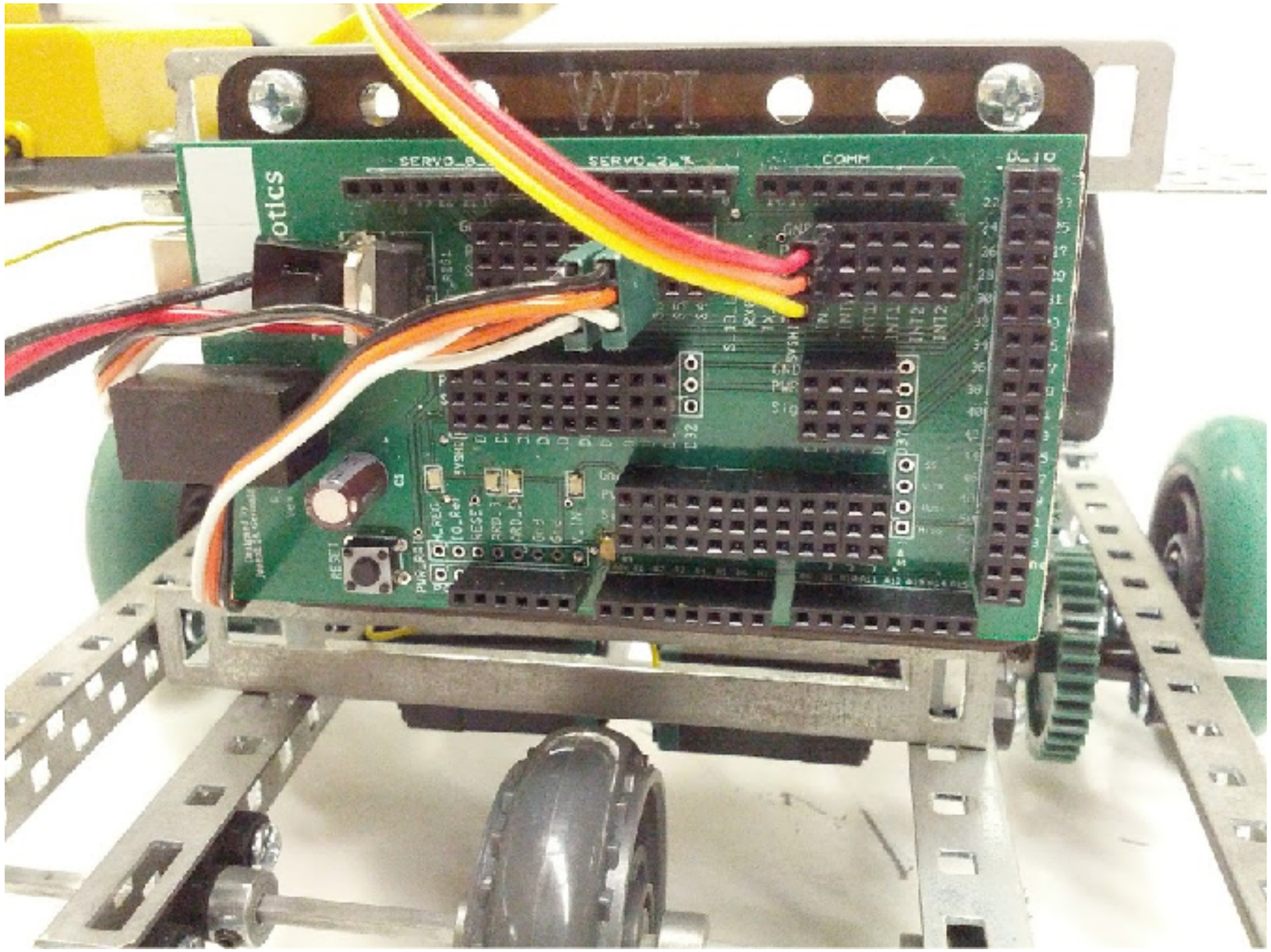
Arduino Specifications

	Mega 2560	Uno
Digital I/O (including PWMs)	54	14
Analog inputs	16	6
PWM outputs	15	6
Serial ports	4	1
Flash memory	256Kb	32Kb
SRAM	8Kb	2Kb

Aduino Mega


PWM ports
Communications
USB Port
Digital I/O
Power connector
Analog inputs
MADE IN ITALY
COMMUNICATION
ARDUINO
MEGA
2560
POWER
ANALOG IN
DIGITAL
WWW.ARDUINO.CC

RBE Shield



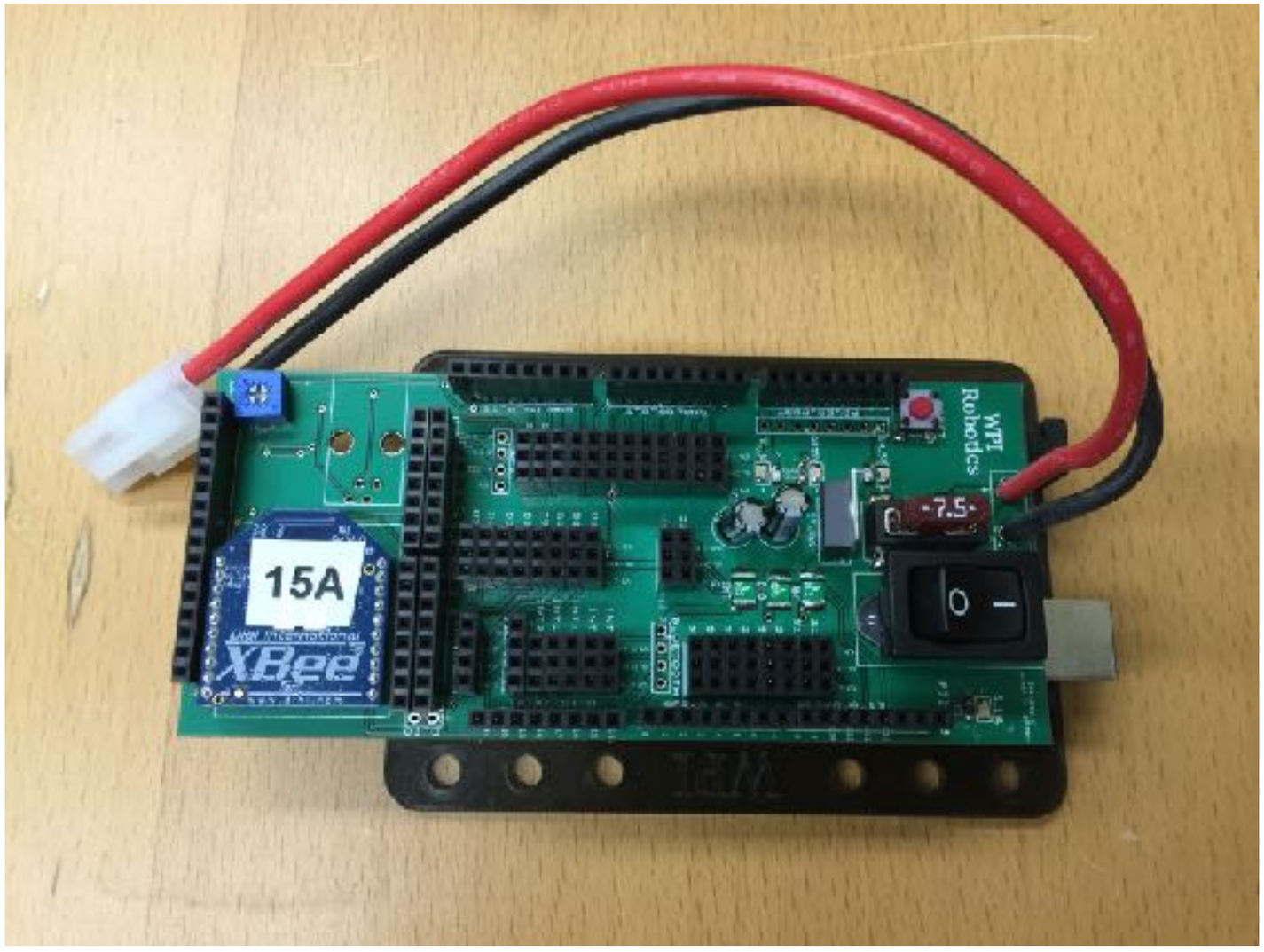
Notice Sig, PWR, GND references on connectors

Controller (gamepad)

XBee based controller

Links to receiver on the Arduino shield

Xbee module



XBee module connects the Arduino to the gamepad. Must be matched pair.

Servos and Motors

- Motors: continuous rotation
- Servos: rotate about 100 degrees
- Both need speed controllers and connect to PWM ports

Motor

Servo

Programming

Programs are simply a series of steps that you want to robot to follow

For these robots they are written in the C programming language

Steps

```
Start driving forward
Wait 2 seconds
Stop driving
Start turning left
Wait 750 ms
Move arm down
Grab ball
Move arm up
.
.
.
.
.
```

C program

```
robot.drive(100);
delay(2000);
robot.stop();
robot.turn(100);
delay(750);
arm.moveto(30);
gripper.close();
arm.moveto(120);
.
.
.
.
.
```

Functions

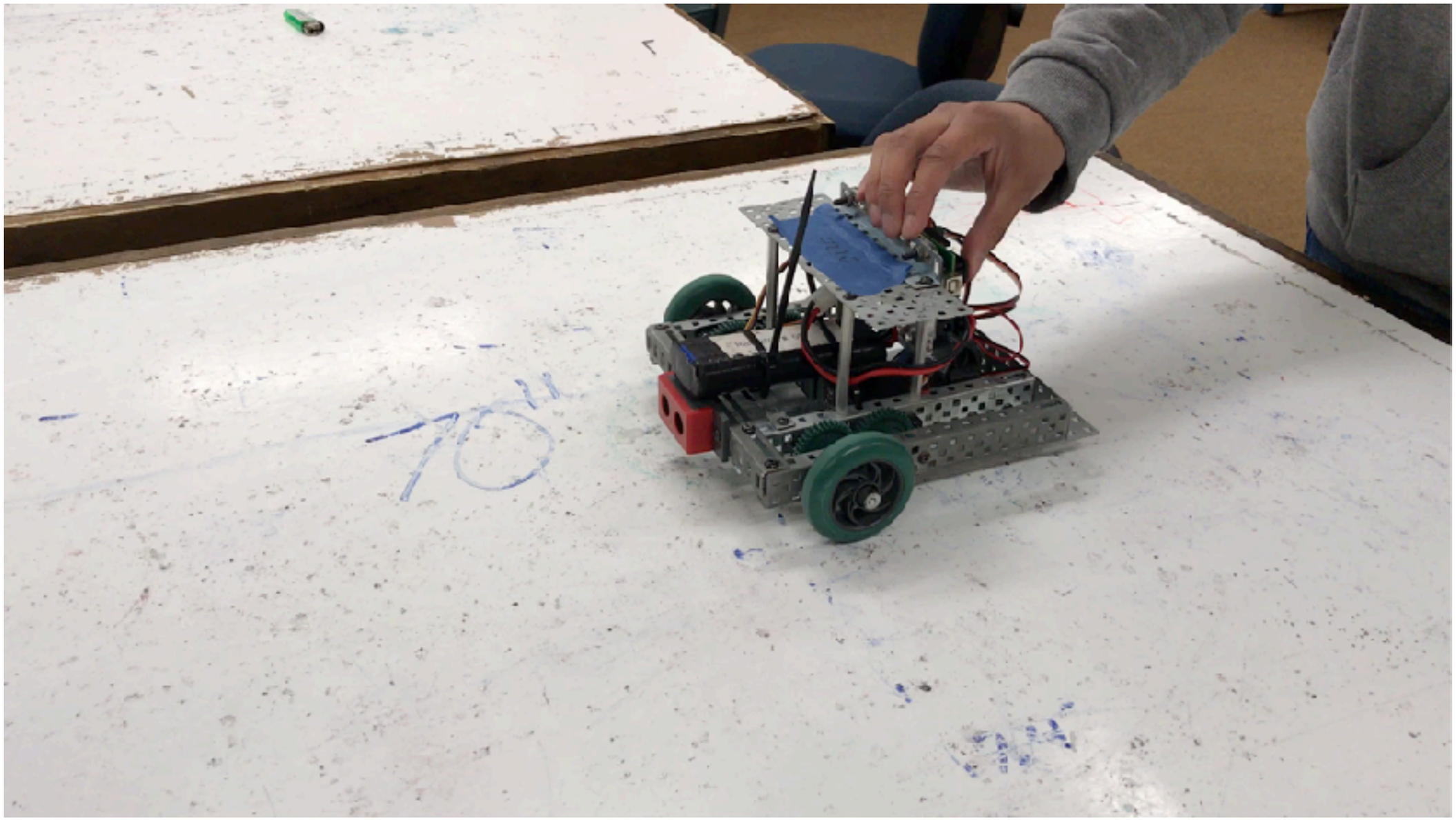
- Giving a name to a group of steps so you can refer to it later

Arduino programs

- The code inside the setup() function is run once at the start of the program
- The code inside the loop() function is run repeatedly

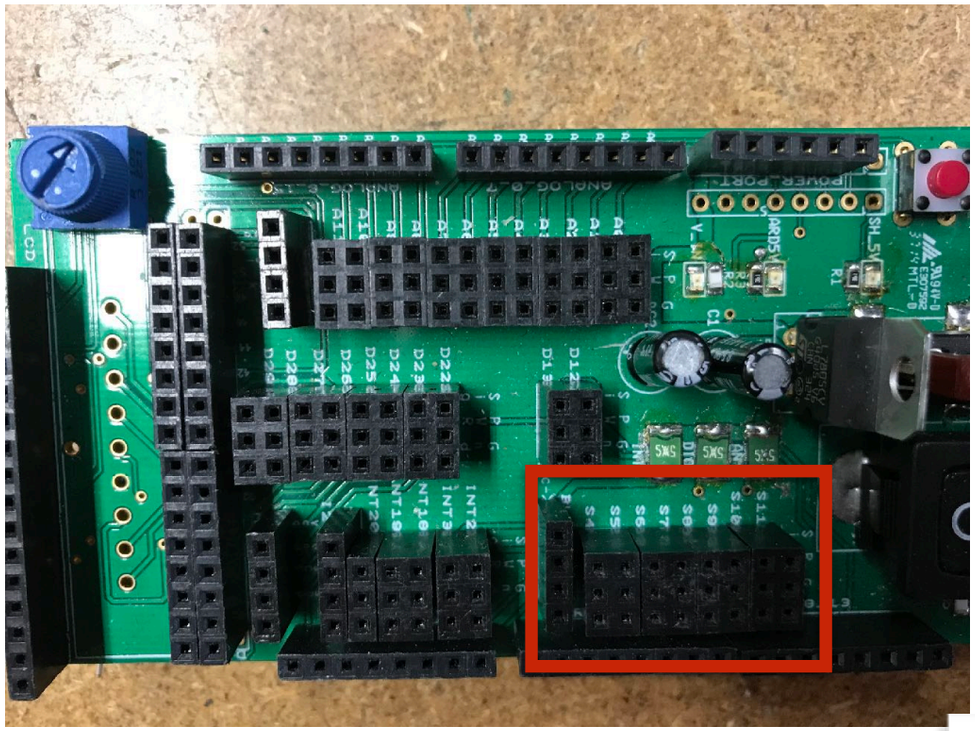
Your first challenge

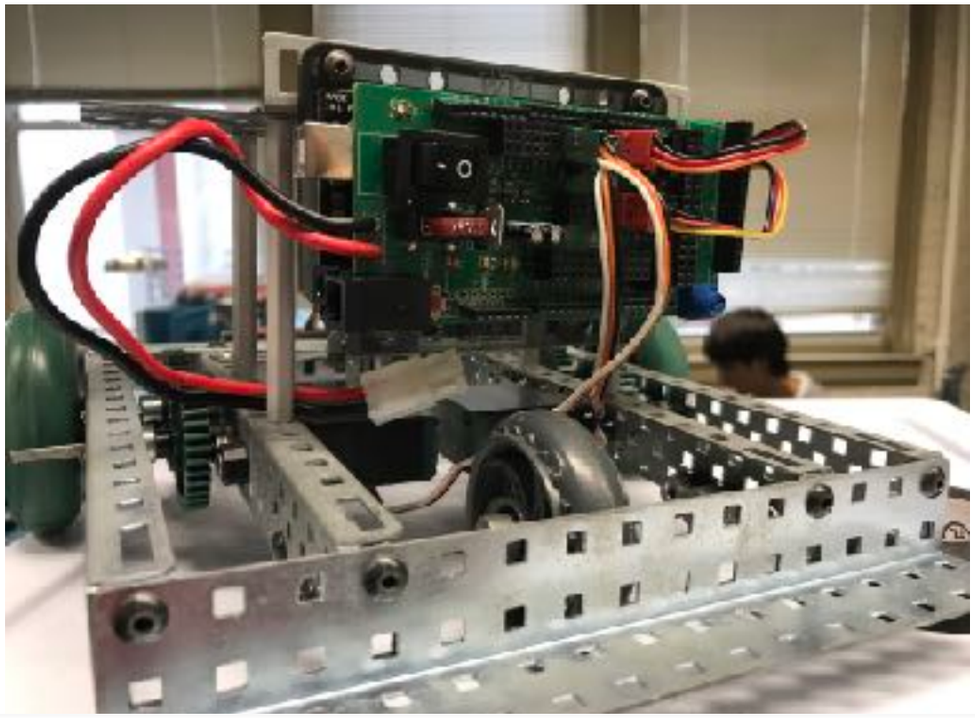
You start with this program

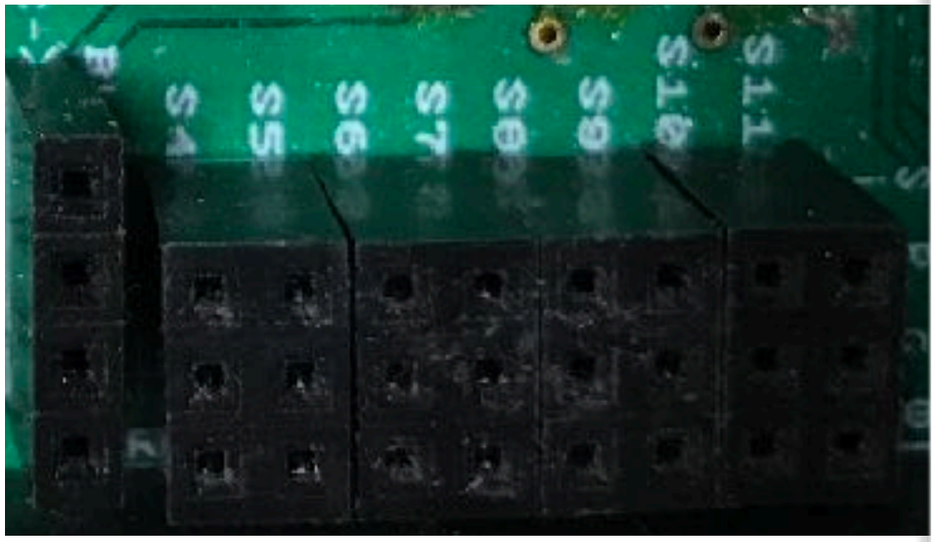


and make the robot drive in a square instead

RobotDrive object








```
#include <RobotDrive.h>

const int leftMotorPin = 5;
const int rightMotorPin = 4;

RobotDrive robot(leftMotorPin, rightMotorPin);
```

RobotDrive object

```
void setup() {
  robot.setup();
}
```

Set up the RobotDrive to work

Then the driving

```
void loop() {
  robot.drive(100);
  delay(1000);

  robot.stop();
  delay(1000);

}
```

Drive full speed forward and wait 1 second (1000ms)

…then stop the robot and wait 1 second

Add a turn

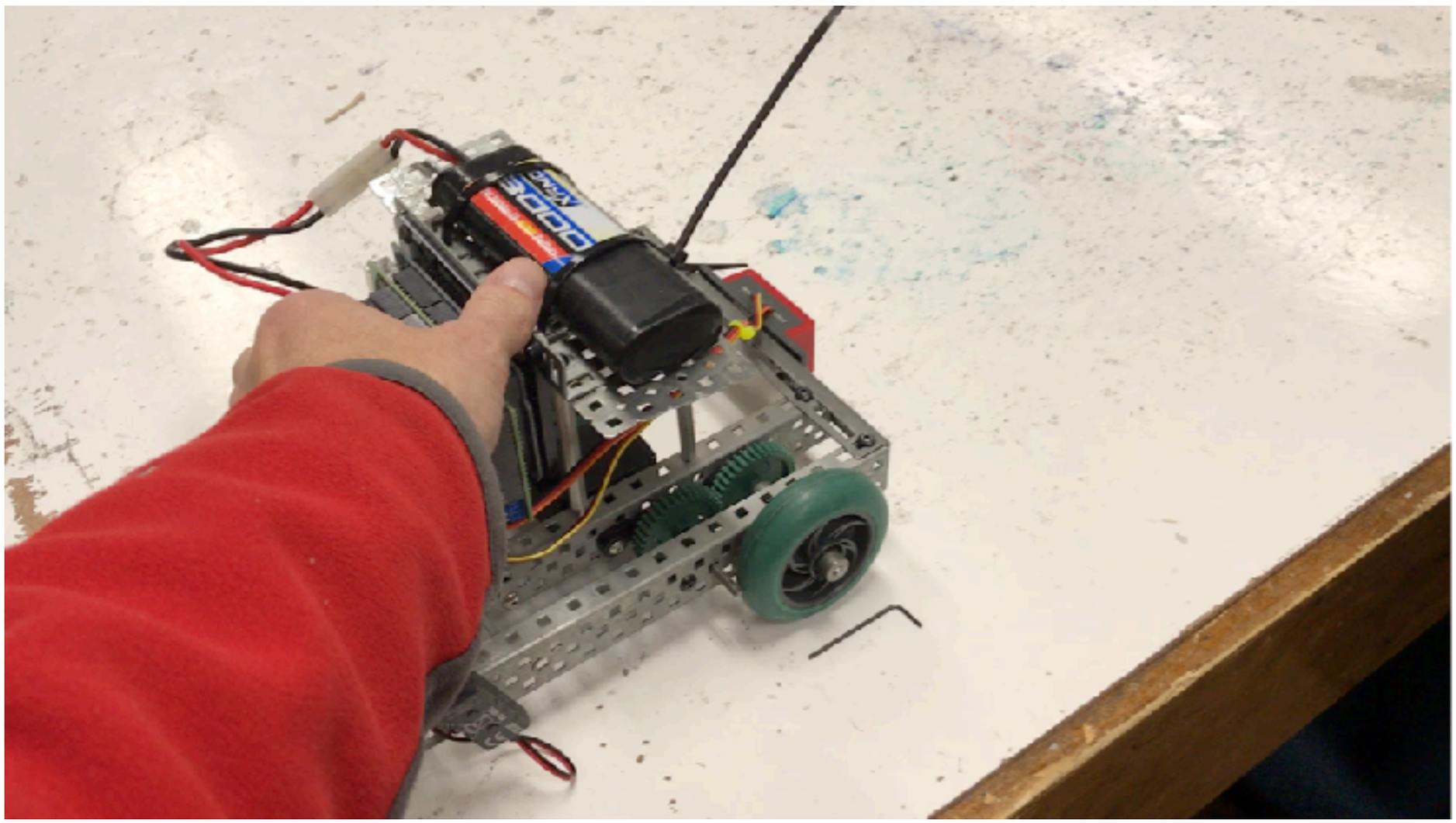
```
void loop() {
  robot.drive(100);
  delay(1000);

  robot.stop();
  delay(1000);

  robot.turn(100);
  delay(800);

  robot.stop();
  delay(1000);
}
```

Start the robot doing a turn in place for 800ms

Then stop the robot for 1 second

Your second challenge

Drive until 10” from wall, then stop



Use a sensor

Ultrasonic rangefinder gives the distance to an object in inches

Sensors allow the robot to understand it's state and the world around it

The driving setup is the same

```
const int leftMotorPin = 5;
const int rightMotorPin = 4;

RobotDrive robot(leftMotorPin, rightMotorPin);
```

Add the rangefinder

```
const int pingPin = 22;
const int echoPin = 2;

const int leftMotorPin = 5;
const int rightMotorPin = 4;

RobotDrive robot(leftMotorPin, rightMotorPin);

ultrasonic ultra(pingPin, echoPin);
```

The ping pin and the echo pin

Set up the ultrasonic rangefinder just like the RobotDrive

And drive while more than 10 inches

```
void loop() {
  if (ultra.distance() > 10)
    robot.drive(50);
  else
    robot.stop();
}
```

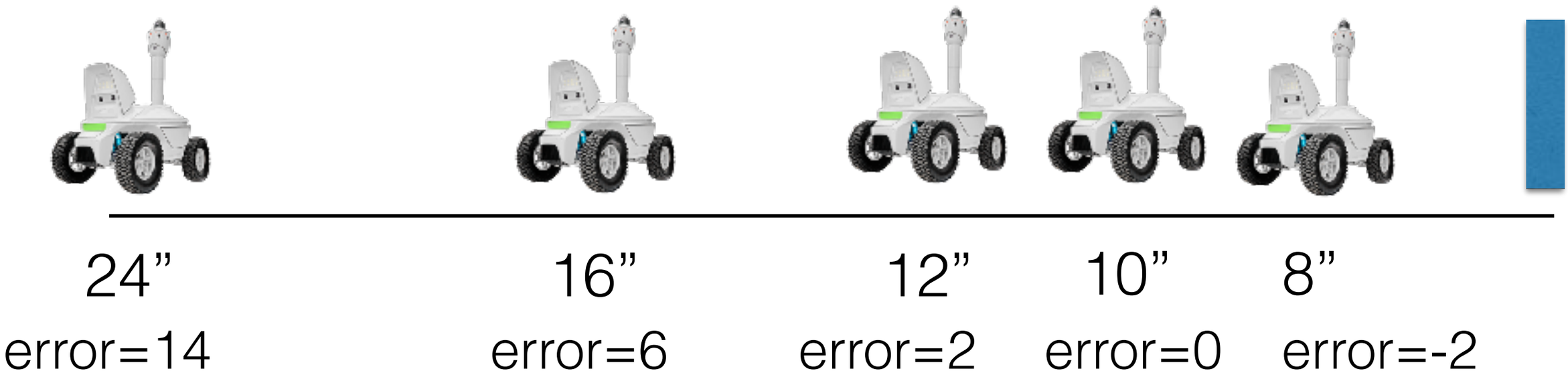
What went wrong?

- Inertia carries robot past 10 inches
- What can we do?
  - Stop 12” from wall to allow 2” of coasting?
- What’s wrong with this strategy?
  - Differences in battery charge
  - Differences in driving surface
  - Differences in slope
  - etc…

Proportional Control

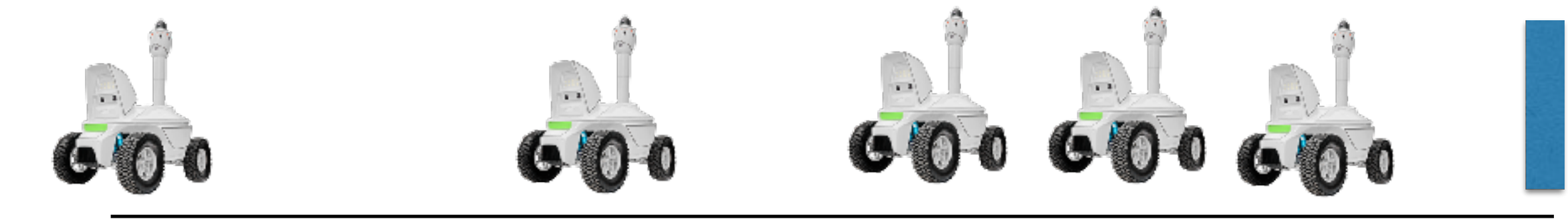
We want the robot to stop 10” from the wall so the **set point** is 10

Compute the distance from the set point and call it the **error**



Make the robot driving speed **proportional** to the error. As the error gets smaller, the robot drives more slowly

Proportional Gain



24” 16” 12” 10” 8”

error=14 error=6 error=2 error=0 error=-2

These error values are too small to make the motors move

We can multiply the values by some constant to make the values bigger

Adding proportional control

```
const int Kp = 1;

const int setPoint = 10;

void loop() {
  int error = ultra.distance() - setPoint;
  robot.drive(Kp * error);
  delay(50);
}
```

Compute the set point

Drive at a speed proportional to the set point

What if Kp is wrong

- What if Kp is too large?
- What if Kp is too small?
- We want you to try to find a value that's correct
    - But look what happens if it's too big and what happens if it's too small