the “Board of Education”

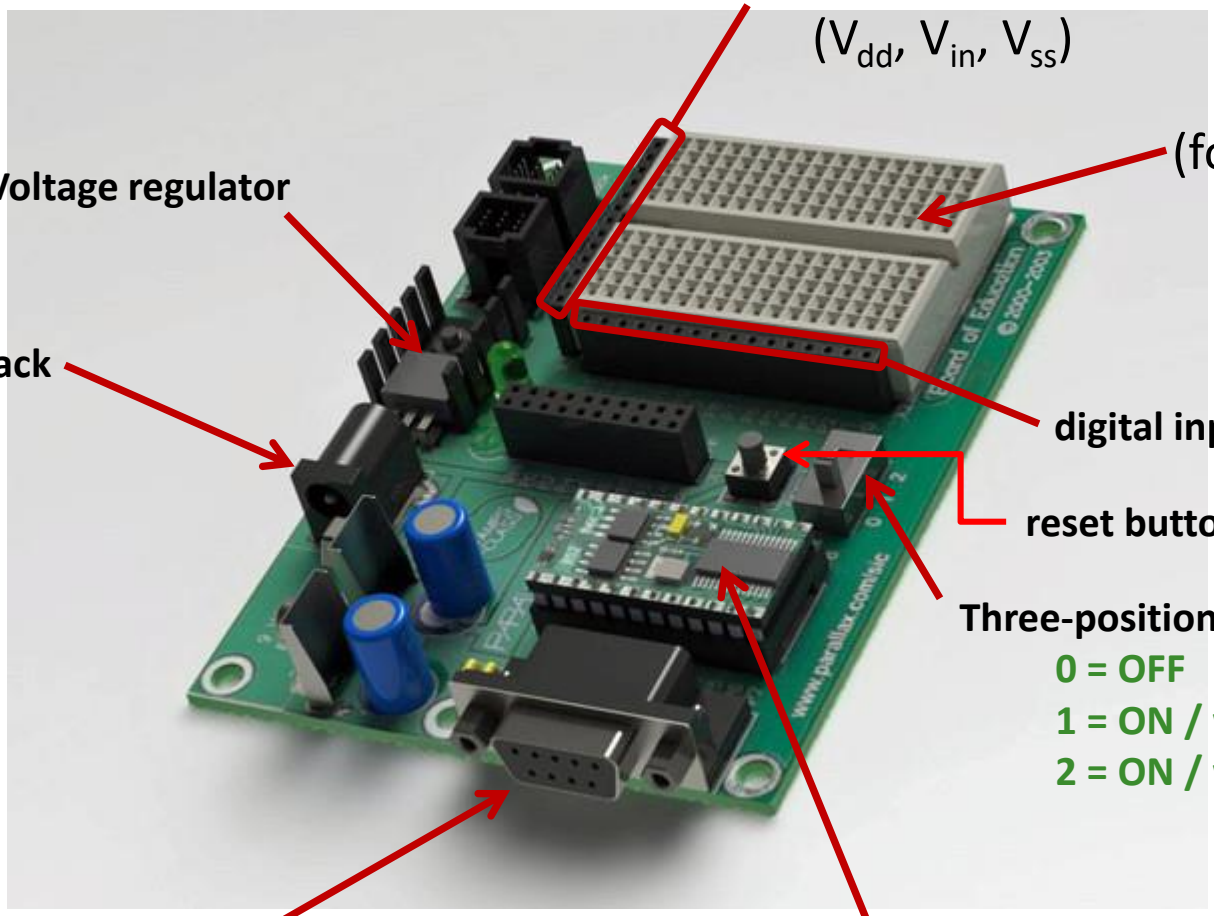


image credit:
www.turbosquid.com/3d-models/parallax-board-education-3d-model/705602

hooking up servo motors

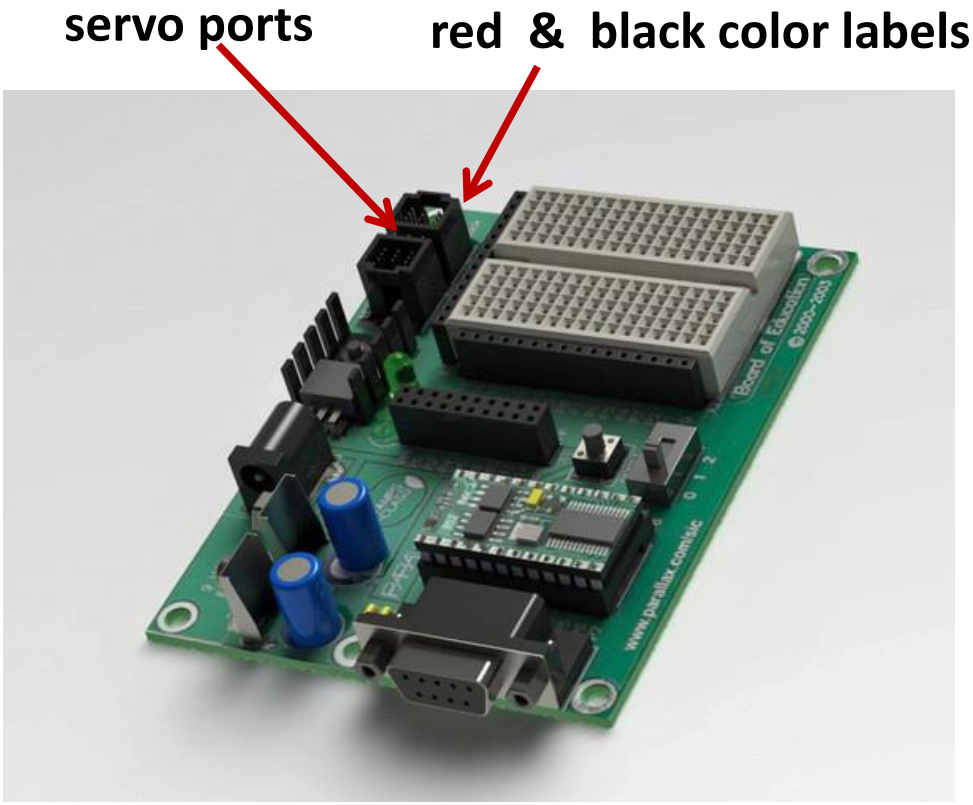
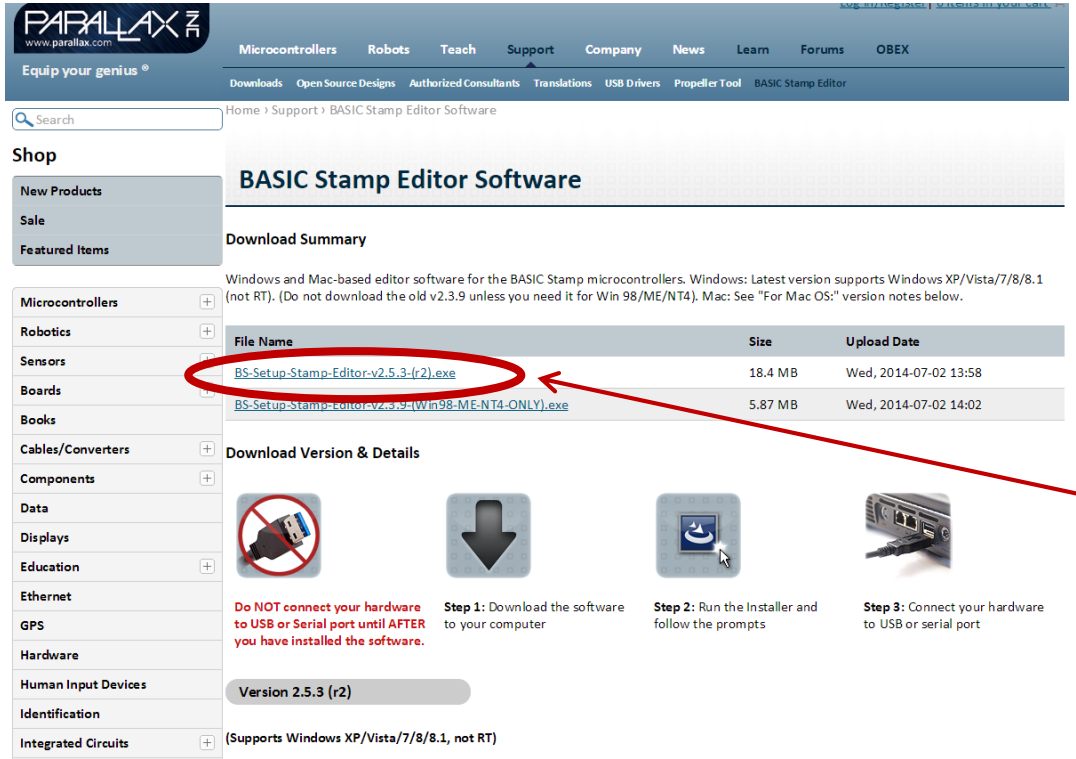
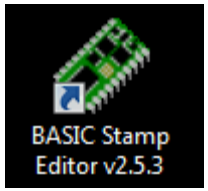


image credit:
www.turbosquid.com/3d-models/parallax-board-education-3d-model/705602

install software to “program” car

https://www.parallax.com/downloads/basic-stamp-editor-software



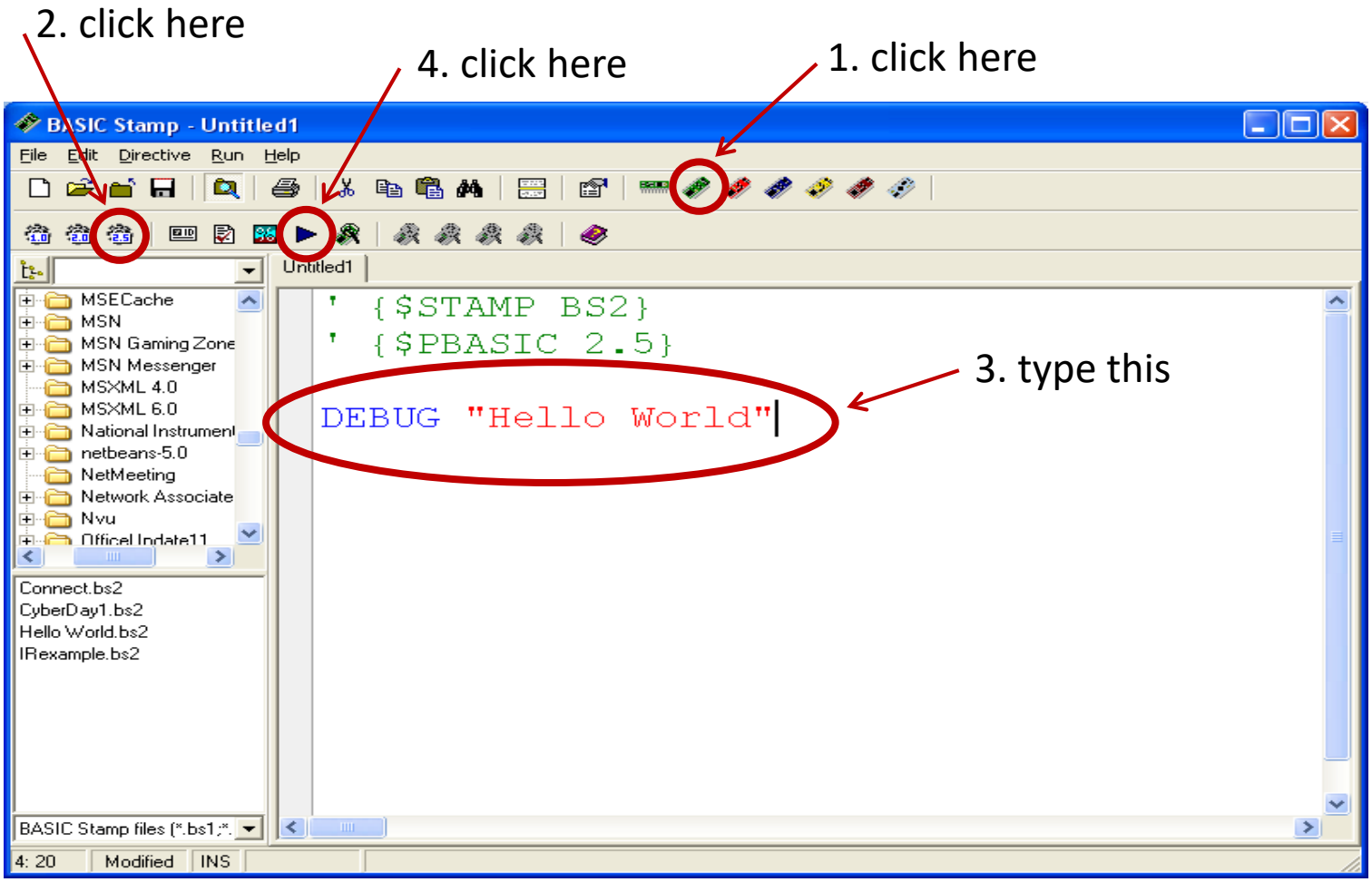


once installed, an icon like this should be available on your computer

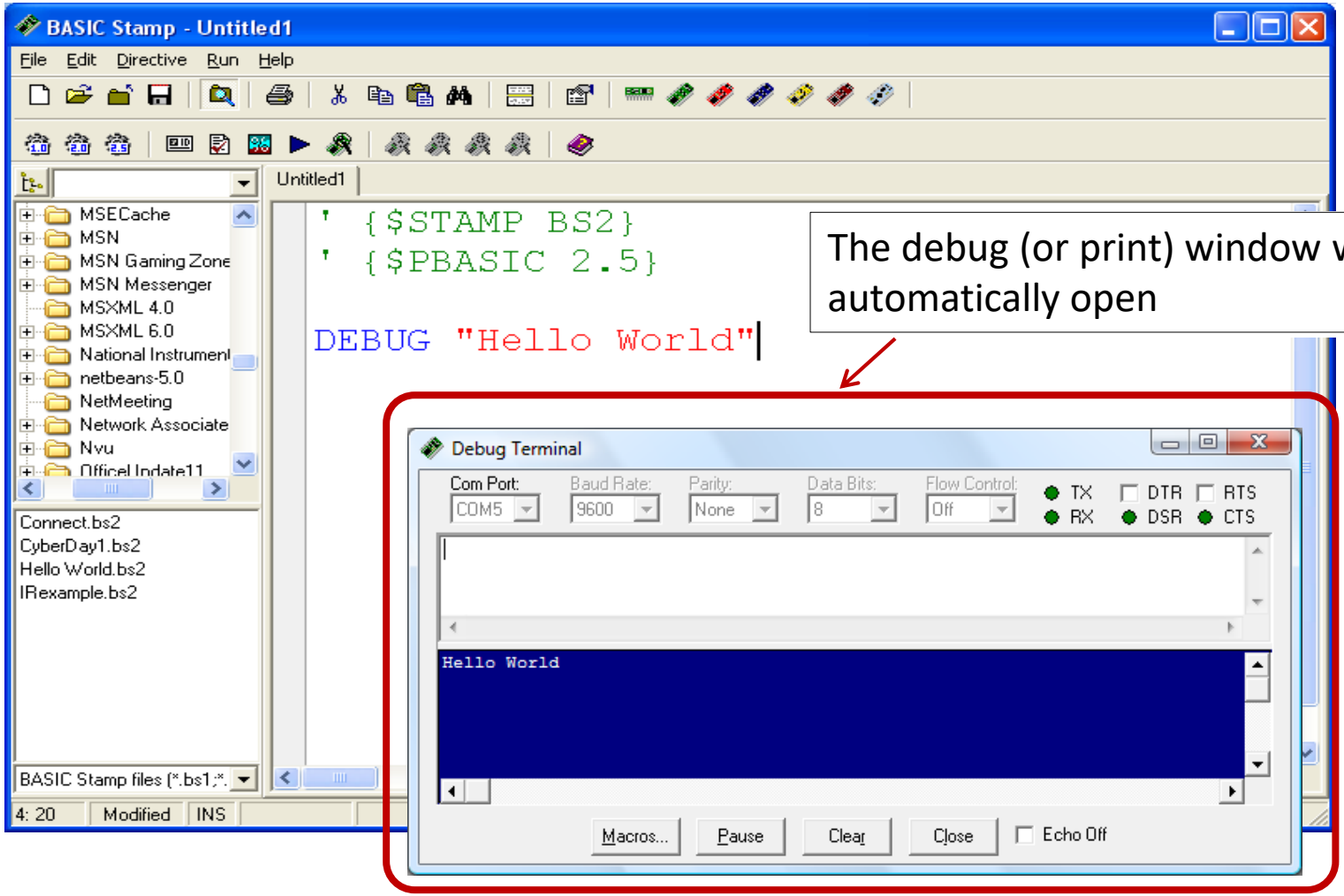
click here

Just copy 18MB file off the thumb drive to speed things up.

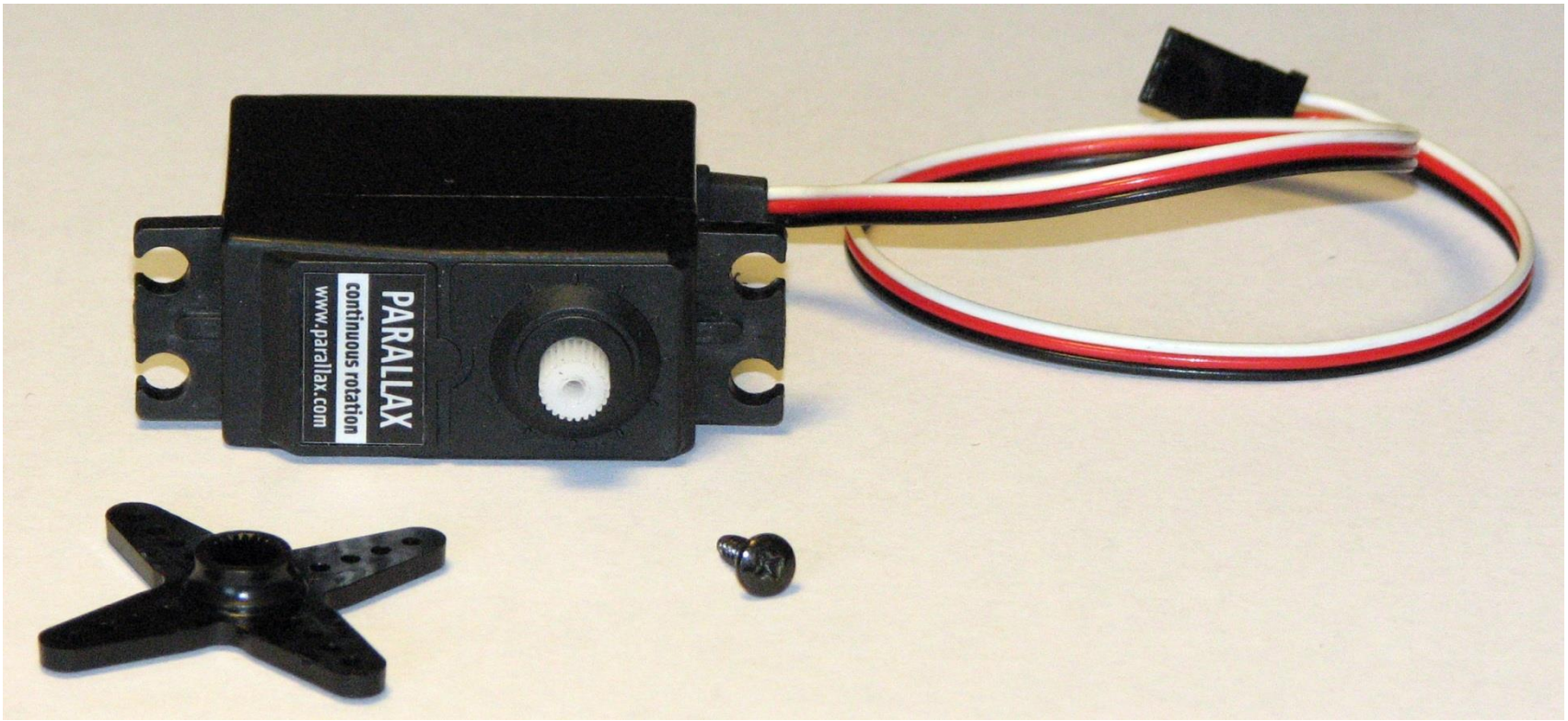
write a simple program



“Hello World” program output



the motors are called servos



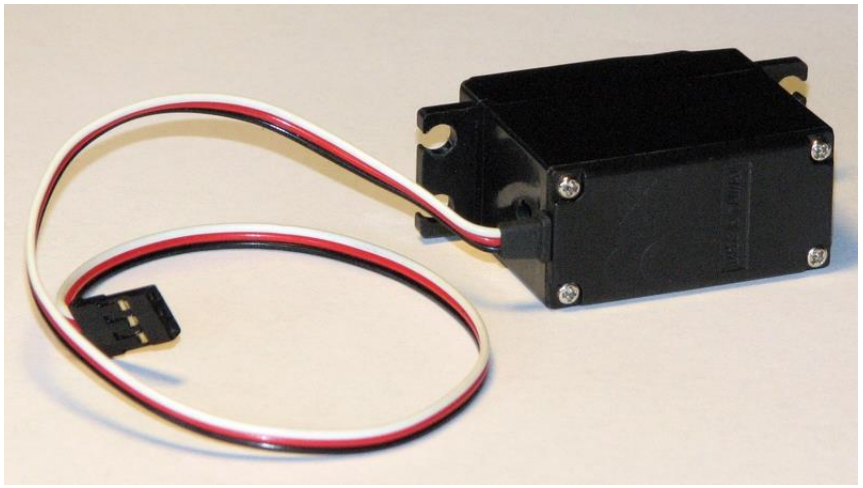
wires to power & control servo

white = signal

red = 5V

black = Gnd

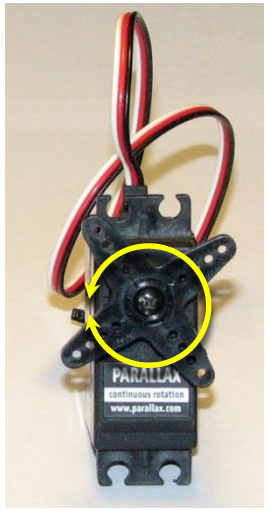
output shaft



types of servos

continuous rotation

can rotate all the way around in either direction

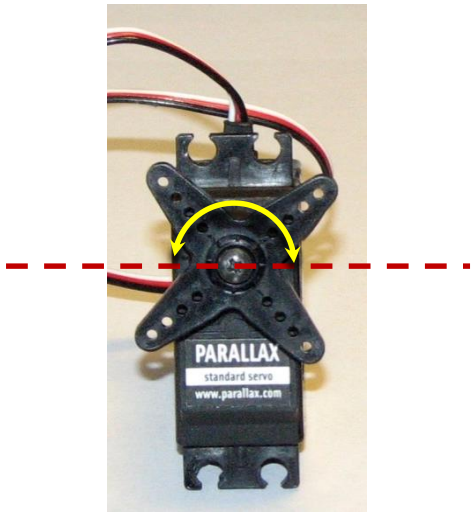


white wire tells servo

which way to spin & how fast to spin

standard

can only rotate 180 degrees

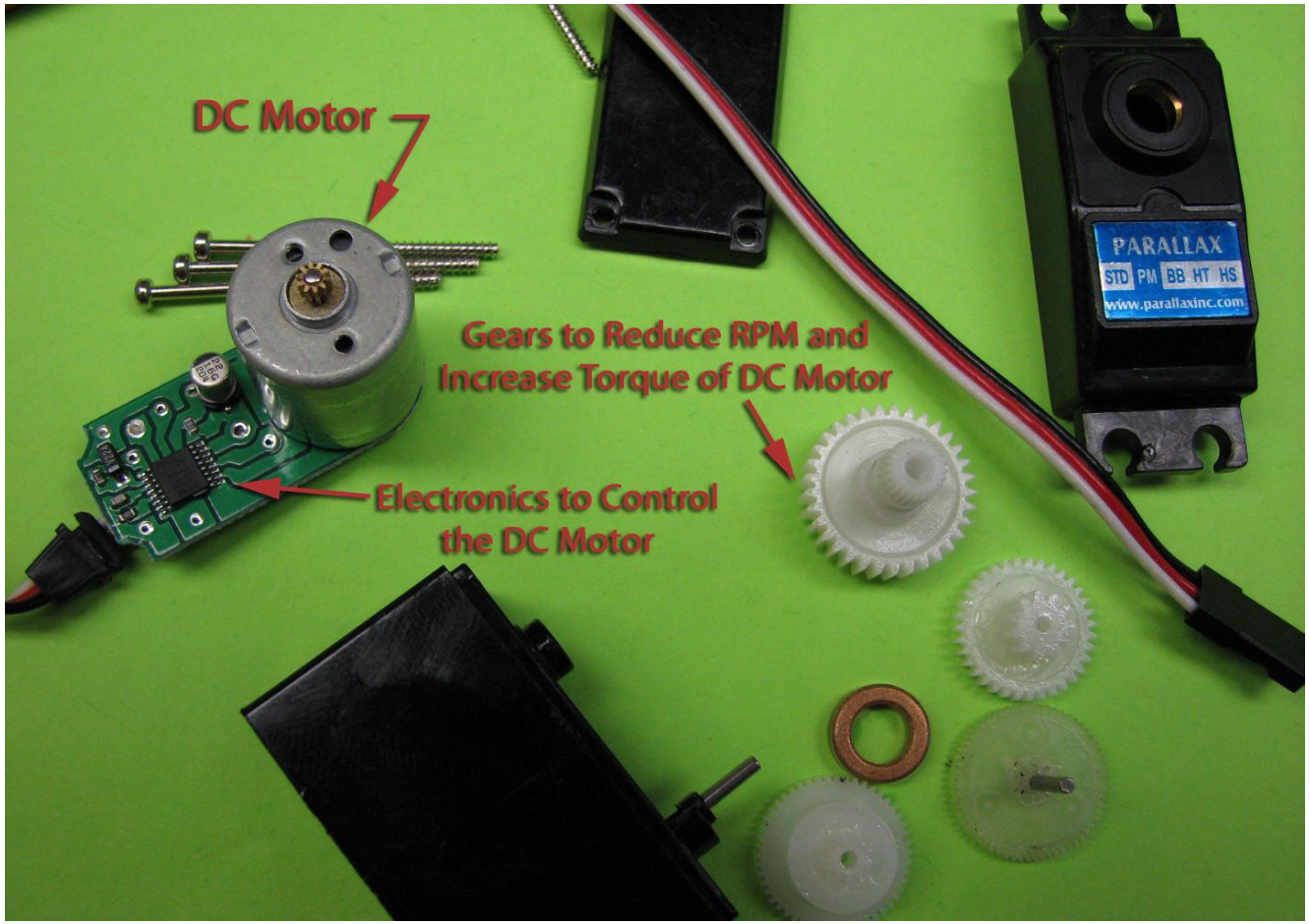


white wire tells servo

which position to hold

servo components

1. small DC motor
2. gearbox with small plastic gears to reduce the RPM and increase output torque
3. special electronics to interpret a pulse signal and deliver power to the motor



making a wheel rotate continuously

```
' {$STAMP BS2}
' {$PBASIC 2.5}

DO
    PULSOUT 13, 650
    PAUSE 20
LOOP
```

```
' {$STAMP BS2}
' {$PBASIC 2.5}

DO
    PULSOUT 13, 750
    PAUSE 20
LOOP
```

```
' {$STAMP BS2}
' {$PBASIC 2.5}

DO
    PULSOUT 13, 850
    PAUSE 20
LOOP
```

Tuning a servo *(also known as "centering" a servo)*

```
' {$STAMP BS2}
' {$PBASIC 2.5}

DO
    PULSOUT 13, 750
    PAUSE 20
LOOP
```

If you have the code shown running, the servo connected to port 13 should not be turning.

If the servo is turning, then adjust the potentiometer inside the servo as shown until it stops.

ONLY TINY MOVEMENTS OF THIS POTENTIOMETER ARE TYPICALLY NEEDED!

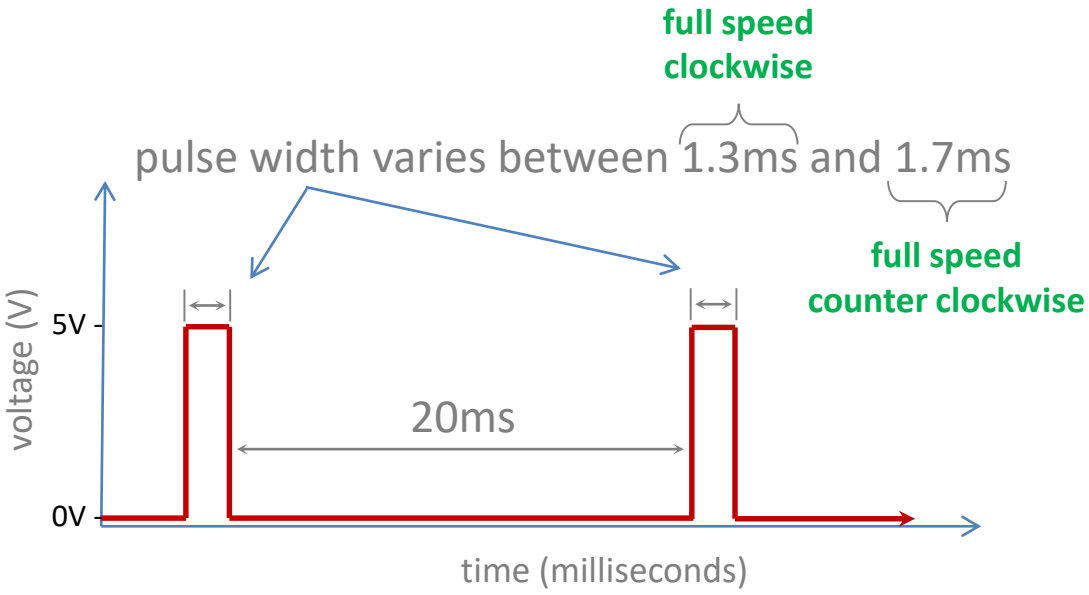
how the control works

```
' {$STAMP BS2}
' {$PBASIC 2.5}



DO
    PULSOUT 12, 650
    PAUSE 20
LOOP
```

$$pulse = 650 \cdot 2\mu s = 1300\mu s = 1.3ms$$

$$pulse = 750 \cdot 2\mu s = 1500\mu s = 1.5ms$$

$$pulse = 850 \cdot 2\mu s = 1700\mu s = 1.7ms$$



PULSOUT argument	pulse width (µs)	servo action
650	1300	full speed CW
700	1400	~½ speed CW
750	1500	stopped
800	1600	~½ speed CCW
850	1700	full speed CCW

speed not linear with pulse duration!

subroutines
(GOSUB)

GOSUB forward *causes the program to look ahead to find and run a subroutine named "forward"*

You must type **END** *at the end of the main part of your code so that the space afterward can be used to define subroutines*

subroutines are named by typing a colon after the name

RETURN *causes the program to go back to the line after the instruction that called the subroutine*

subroutines allow a programmer to reuse the same code multiple times as a program is executed

```
' {$STAMP BS2}
' {$PBASIC 2.5}

counter VAR Word

GOSUB forward
PAUSE 1000
GOSUB backward
PAUSE 500
GOSUB forward
PAUSE 2000
GOSUB backward
END

forward:
FOR counter = 1 TO 100
PULSOUT 12, 650
PAUSE 20
NEXT
RETURN

backward:
FOR counter = 1 TO 100
PULSOUT 12, 850
PAUSE 20
NEXT
RETURN
```

FOR loops

a **FOR** *loop allows a programmer to execute a piece of code several times in a row, and stop after a specified number of times*

in this example, the variable **counter** *starts at 1 and increases by 1 each time the included code is executed, until* **counter** *reaches 100*

the word **NEXT** *is used to denote the end of the code included in the loop*

dead reckoning navigation

```
' {$STAMP BS2}
' {$PBASIC 2.5}

counter VAR Word
loops VAR Word

loops = 20
GOSUB forward
loops = 13
GOSUB turnleft
END

forward:
    FOR counter = 1 TO loops
        PULSOUT 12, 650
        PULSOUT 13, 850
        PAUSE 20
    NEXT
    RETURN

turnleft:
    FOR counter = 1 TO loops
        PULSOUT 12, 650
        PULSOUT 13, 650
        PAUSE 20
    NEXT
    RETURN
```

main part of program

by setting the number of loops to complete on each type of motion, the amount of time spent for each leg of the journey can be controlled easily (it will take about 20ms per loop)

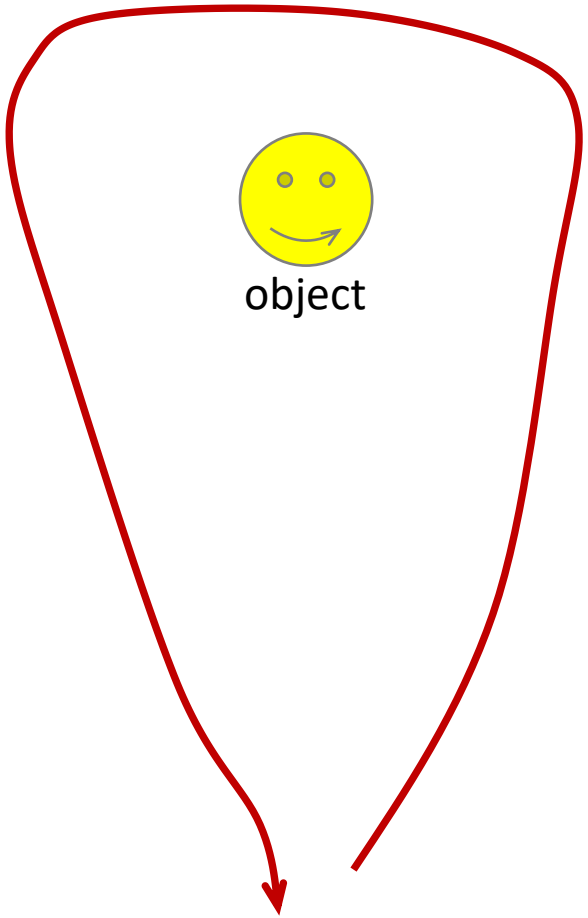
subroutines for defining different kinds of motion

many more could be defined to fully customize how you want to be able to control your bot

turning wheels in the "opposite" direction (i.e. one clockwise, one counter-clockwise) on each side actually makes both sides of the bot go forward in roughly a straight line. this happens because the servo axles face opposite directions.

turning wheels in the "same" direction (i.e. both clockwise) on each side actually makes one side of the bot go forward and one side go backward. this results in a turn. this happens because the servo axles face opposite directions.

play around with car to make it drive around an object



accepting keyboard input (DEBUGIN command)

```
' {$STAMP BS2}
' {$PBASIC 2.5}

key VAR Word

DO
DEBUGIN key
DEBUG "you just pressed ", key, CR
LOOP
END
```

your program will wait until a key is pressed, then store the keystroke into the variable **key**

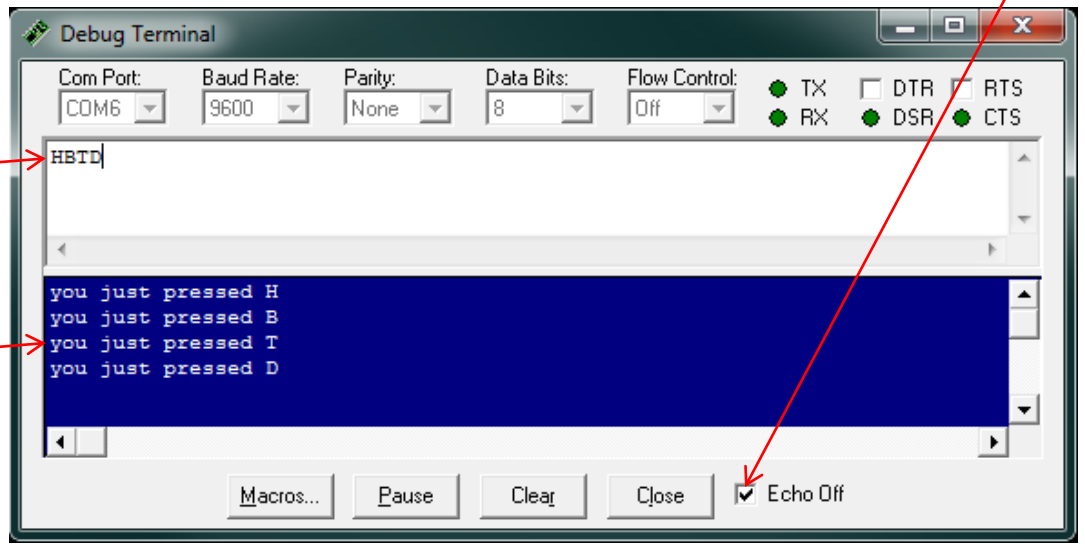
Your bot will generate the "you just pressed" text, then show the value stored in **key**

CR *stands for carriage return…it makes the debug output start a new line*

if this box is not checked, then each keystroke entered will automatically be repeated in the output of the Debug Terminal (i.e. the dark blue area)

type here

text generated by the bot is shown here



keyboard control

```
' {$STAMP BS2}
' {$PBASIC 2.5}

key VAR Word
counter VAR Word
loops VAR Word
loops = 10

DO
DEBUGIN key
IF key = "w" THEN
GOSUB forward
ELSEIF key = "a" OR key = "A" THEN
GOSUB turnleft
ENDIF
LOOP
END

forward:
   FOR counter = 1 TO loops
      PULSOUT 12, 650
      PULSOUT 13, 850
      PAUSE 20
   NEXT
   RETURN

turnleft:
   FOR counter = 1 TO loops
      PULSOUT 12, 650
      PULSOUT 13, 650
      PAUSE 20
   NEXT
   RETURN
```

variable for storing a keystroke

variable for counting loops

variable for setting the number of loops to count
(the number "10" can be changed to tune performance)

this command takes a keystroke from the Debug Terminal and stores it into variable **key**

main loop for continually accepting keyboard input and choosing motion

this line checks the character stored in **key** *to determine if it is a "w". if it is, the* **forward** *subroutine is run*

this line checks for either a lower or uppercase "a". this might be useful to handle accidental "caps lock" keystrokes

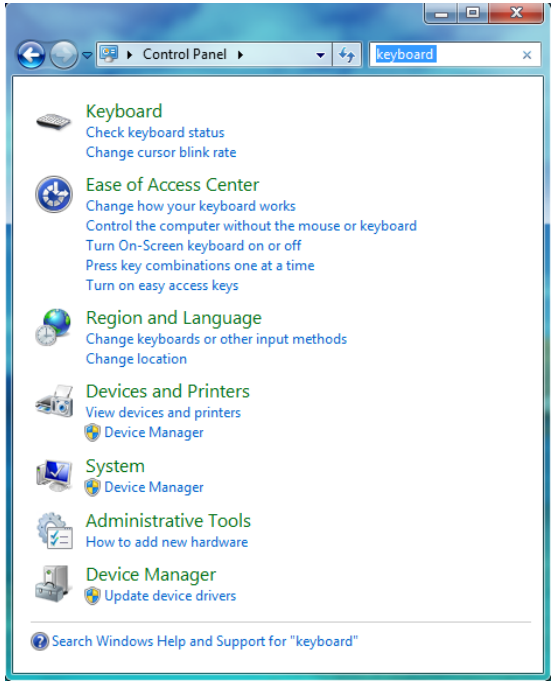
the ELSEIF command is used to check another condition if none of the earlier conditions were met

the ENDIF command is used to end a set of conditions being checked. many more ELSEIF lines may be used before ENDIF

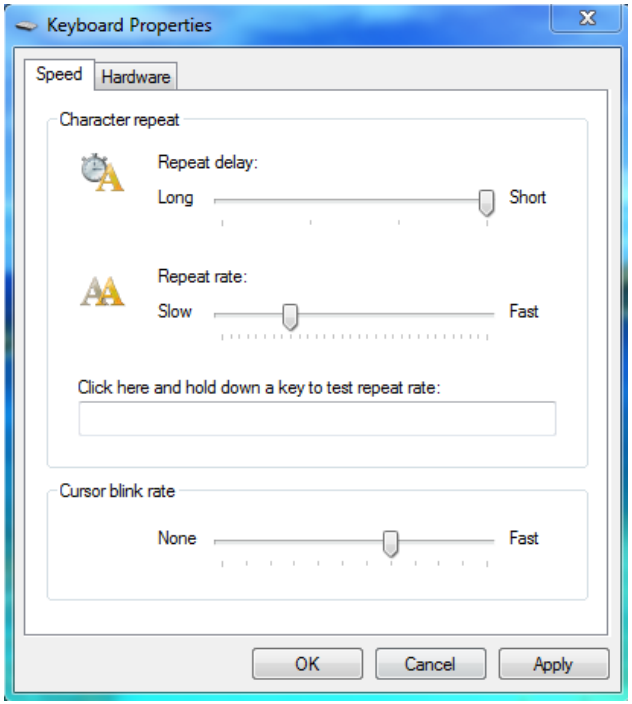
subroutines for defining different kinds of motion
many more could be defined to fully customize how you want to be able to control your bot

Each time one of these subroutines is run, a set of 10 pulses (the value stored in **loops**) *is sent to the servos*

keyboard tuning (key repeat rate and delay)



navigate to control panel, type "keyboard" in the search bar, and select "Keyboard"



- *set the "Repeat delay" all the way to "Short"*
  - *this will minimize the 'stumble' when the bot first begins*
- *set the "Repeat rate" more to the "Slow" end of the scale*
  - *this will make computer lock-ups less likely*
  - *try it at several different settings on the slow end of the scale to find best performance*
- *what is going on?*
  - *using slower setting prevents keyboard buffer overruns*
  - *timing between keystroke events and your bot's brain is better at some repeat rates than others*

play with various types of bot motion.
try to find better mapping from keystrokes to bot activity.

ideas:

- *define several types of turns*
  - *gentle sweeping turn*
  - *basketball pivot*
  - *zero-turn lawnmower*
- *use caps-lock and/or shift as a "mode" toggle*
  - *slow speed mode for detailed movements, fast speed mode for traveling*
  - *sharp turn mode/sweeping turn mode*
  - *movement control mode/attachment control mode*
  - *etc…*
- *this is an opportunity to practice using conditional structures in PBASIC. note that conditional statements can be "nested," i.e. one can be placed inside another.*
- *try having a race between a bot controlled by a person via keyboard control and one set up for dead reckoning*