we continue 2.10
(no need to stay if you know how to
blink an LED from a breadboard)
the microcontroller
many different ones.
what are some **differences** between them?

<30s brainstorming>
add more **functionality:**

- wifi shield
- game controller shield
NodeMCU ESP8266 WiFi Module

this is what we use in class
the breadboard
are the LEDs connected with each other?

<30s brainstorming>
and here?

<30s brainstorming>
now?

&lt;30s brainstorming&gt;
and here?

<30s brainstorming>
how about this?

<30s brainstorming>
would using a cable fix it?

<30s brainstorming>
cables
prototyping cables for your breadboard...
it’s just a normal cable, nothing special about it... you can make your own!
EDS cable stand: cut a piece of cable from the roll
use a cable crimper (or scissors)
insert cable into crimper, then rip off front
now you can **plug it into the breadboard**
let’s do this!

• cut a piece of cable from a cable role
• peel of the plastic from each side
• use in your breadboard

<2 min>
for many things, you need **two cables** (e.g. for USB) one connected to + and one connected to -
where is + and - on the controller?

<30s brainstorming>
3V +

GnD (ground) -
Twisting both cables allows to hold them in place together.
making a twisted cable with +/-

• quick demo

<1 min>
connecting an LED
let’s connect the LED to 3V and G to turn it on (use prototyping cables) <2 min>

once it’s on, please disconnect again (it will fry after a while because we miss a resistor)
basic circuit math
need to know **required voltage and current** for each circuit component

![LED Image](http://www.mouser.com/Optoelectronics/LED-Lighting/LED-Emitters/Standard-LEDs-Through-Hole/_/N-b1bc8)

| 7500 mcd | 50 mA | 2.1 V |
3.3V on ESP blows up the LED
2.1V 20mA

blows up the LED
add a resistor (lowers the current)

3.3V on ESP

2.1V 20mA
many different resistors, which one should we use?
Ohm’s Law! 
\[ \Delta V = R \times I \]

\[ \Delta V = \text{given} \]
\[ I = \text{given} \]
\[ R = ? \]

let’s do the math! 

<2 min>

3.3V on ESP

2.1V 20mA

add a **resistor** (lowers the current)
Ohm’s Law!
\[ \Delta V = R \times I \]

\[ \Delta V = 3.3V - 2.1V \]
\[ I = 20\text{ma} \]
\[ R = ? \]

\[ R = \frac{3.3V - 2.1V}{0.02A} \]

\[ R = 60\Omega \text{ (ohm)} \]
resistor

> 60Ω causes LEDs to be less bright
< 60Ω might blow up LEDs
but which one is it?
Resistor colour code

1st Digit  | 2nd Digit  | 3rd Digit  | Multiplier | Tolerance
---|---|---|---|---
0 | 0 | 0 | 1 | 1%
1 | 1 | 1 | 10 | 2%
2 | 2 | 2 | 100 |
3 | 3 | 3 | 1000 |
4 | 4 | 4 | 10000 |
5 | 5 | 5 | 100000 |
6 | 6 | 6 | 1000000 |
7 | 7 | 7 | 10000000 |
8 | 8 | 8 | 100000000 |
9 | 9 | 9 | 1000000000 |

5 - band code

4 7 0 00  ± 1 %

47 kΩ ± 1 %

4 - band code

5 6 000  ± 5 %

56 kΩ ± 5 %
Resistor color code calculator

The calculator above will display the value, the tolerance and performs a simple check to verify if the calculated resistance matches one of the EIA standard values. Select the first 3 or 4 bands for 20%, 10% or 5% resistors and all 5 bands for precision (2% or less), 5-band resistors. Hover above the tolerance for min. and max. range values.

If you want to find out the color bands for a value, use the tool on the left. Enter the value, select the multiplier (Ω, K or M), the desired precision and hit 'Display resistor' or ENTER. You can also type in resistor values in shorthand notation like 1k5, 4M7 or 100R.
let's modify our circuit to include the resistor! (you should have a 60 ohm resistor in your bag).

<2 min>

3.3V

60 ohm

shoutkey.com/bring
serial and parallel circuits
serial circuit

parallel circuit
this is what you need for your multi-touch pad:

\[ R = \frac{3.3V - 2.1V}{0.02A \times \# \text{ of LEDs}} \]
soldering & summary
prototyping cables are great for iterating and testing but they easily fall off and disconnect
solder for permanent connection
stay if you want to solder!
otherwise see you on friday!

a few things to do some time…
• read some **books & tutorials**
• watch some **youtube videos**
• doing this a bit on the side goes a long way…
- play around with some sensors
let’s solder & make this a real cable

• solder the male-to-make connectors on

<5 min>
let’s solder two LEDs together

• take two LEDs
• warm up the soldering iron
• use solder and connect them
• warm solder on LED to disconnect again

<5 min>