Product development & engineering design

ME-320

PROF. JOSIE HUGHES

Lecture 9: CAD & Electrical Drawings

Schedule

Week 7	*22/10/2025*	*Break*	
Week 8	29/10/2025	2nd Design Review with TAs	Review session in SPOT
Week 9	05/11/2025	Electronics & prototyping	Lecture
Week 10	12/11/2025	Engineering Drawings	Lecture
Week 11	19/11/2025	Design for Manufacture, Sustainability	Lecture
Week 12	26/11/2025	3rd Design Review with TAs	Review session in SPOT
Week 13	03/12/2025	Introduction to the robot arm	SPOT
Week 14	10/12/2025	Preparation and testing (competition for anyone wanting to go early)	SPOT
Week 15	17/12/2025	Final Testing/Competition	SPOT

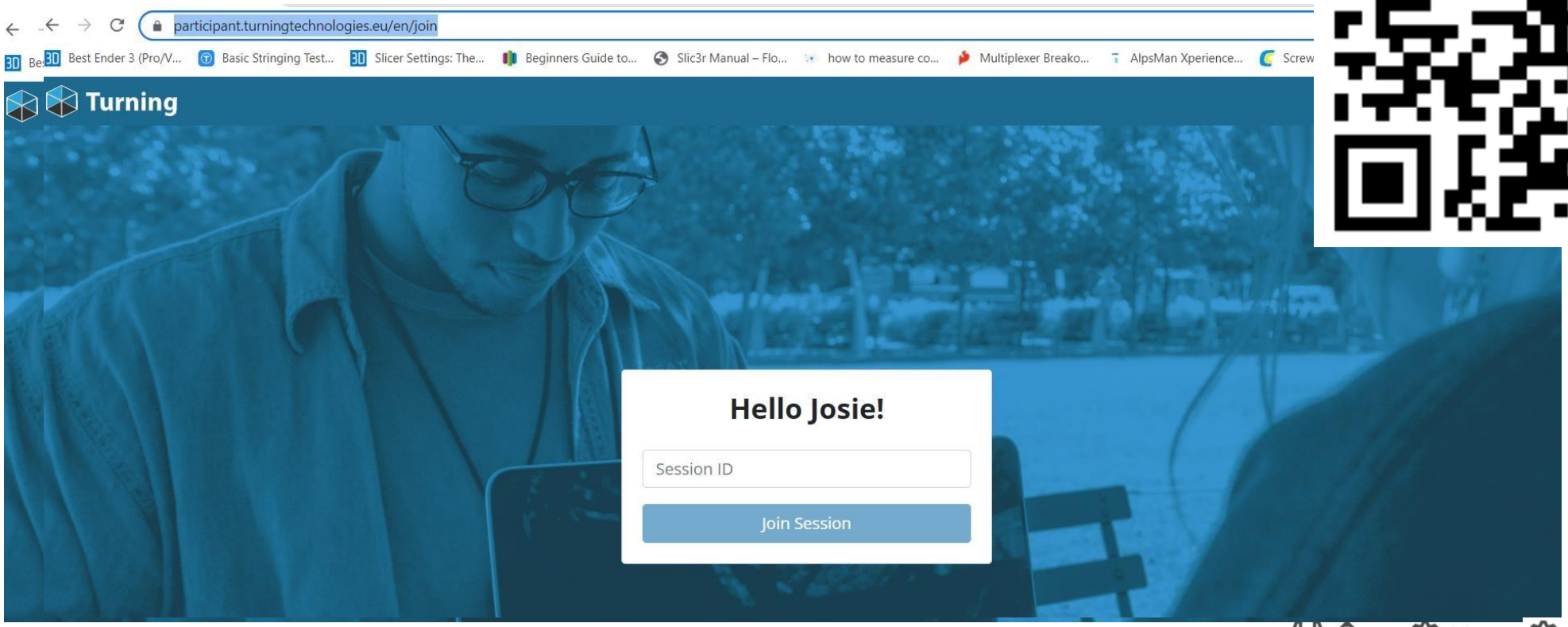
Engineering Drawings Quiz

https://participant.turningtechnologies.eu/en/join

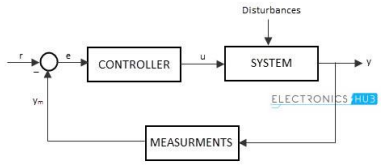
https://participant.turningtechnologies.eu

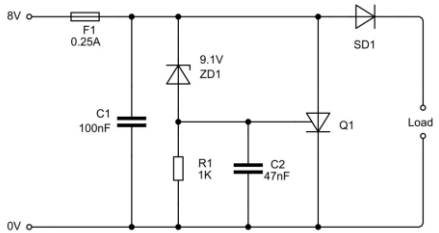
SessionID: datadriven

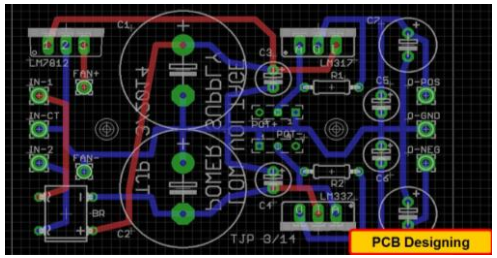
https://ttpoll.eu/p/datadriven



Representing Electronics & Systems







System Diagram

Schematic Diagrams

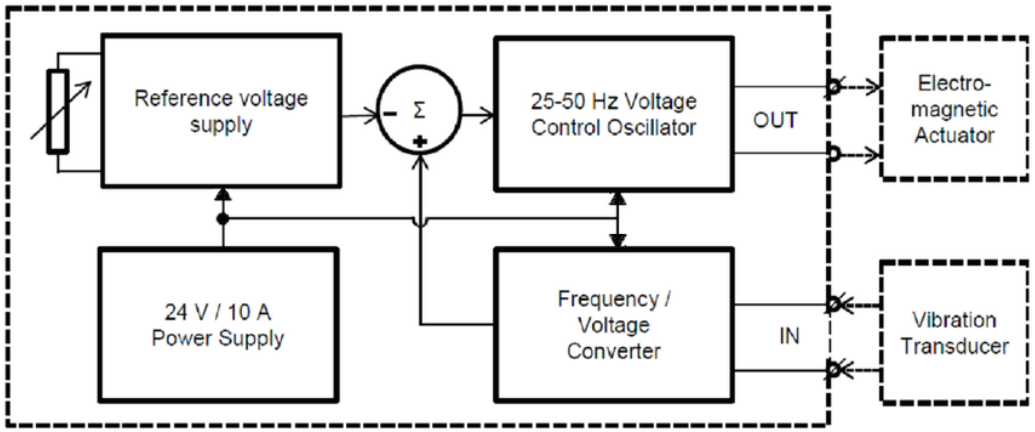
Layouts

High level systems, signals, interactions.

Electronics

Specific Layout

System Diagrams



- Key systems are included
- Signals and connections
  - Power signals
  - Data/information signals
- Direction of arrows matters!
- Indicate the different subsections

For a robot gripper with following what would our system diagram look like?

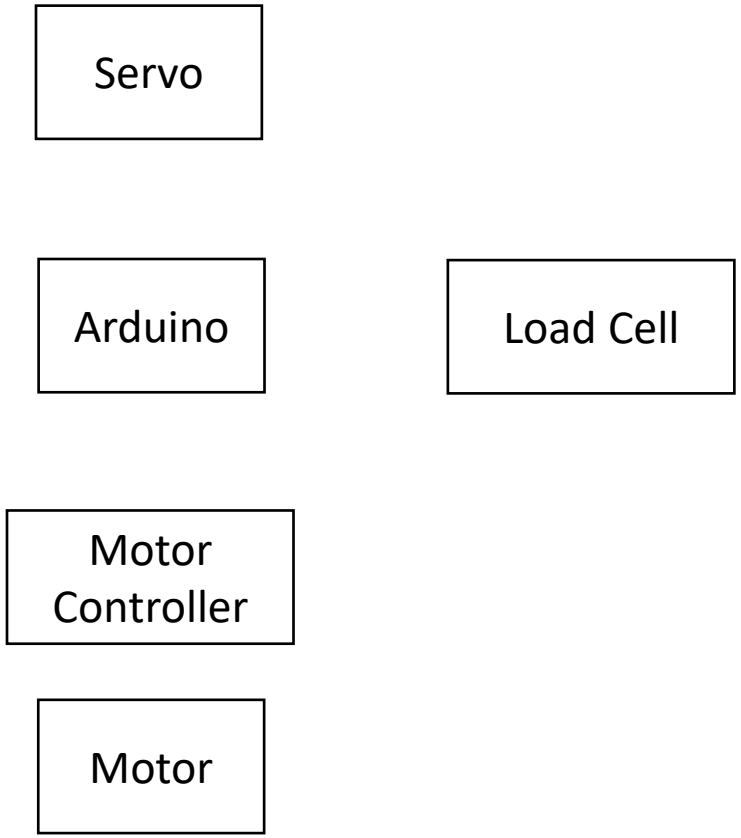
Servo, Motor, Motor Controller, Microcontroller, Load Cell

System Diagrams

For a robot gripper with following what would our system diagram look like?

Servo, Motor, Motor Controller, Microcontroller, Load Cell

What direction should the arrows go?

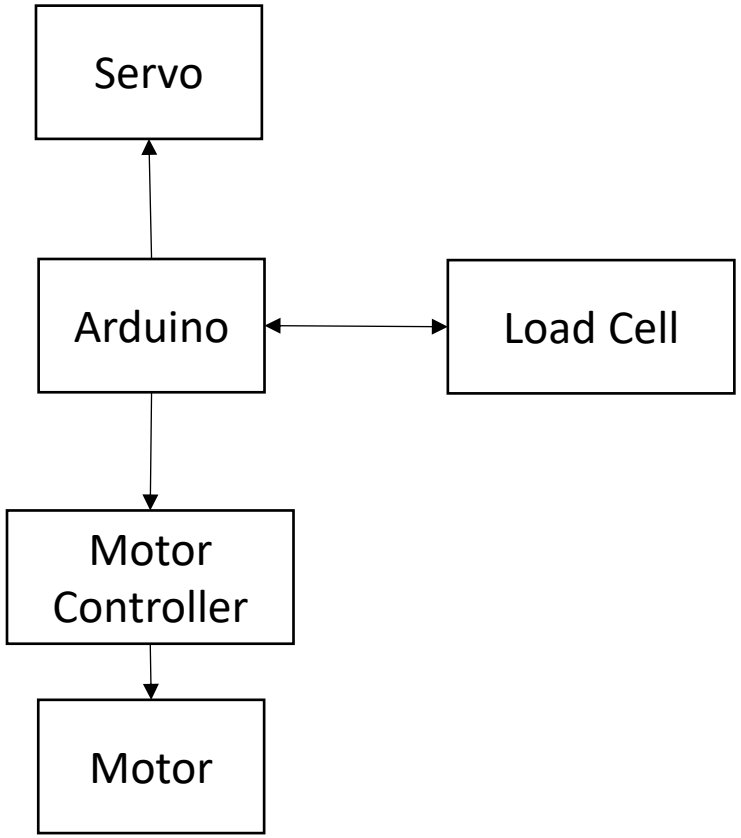


System Diagrams

For a robot gripper with following what would our system diagram look like?

Servo, Motor, Motor Controller, Microcontroller, Load Cell

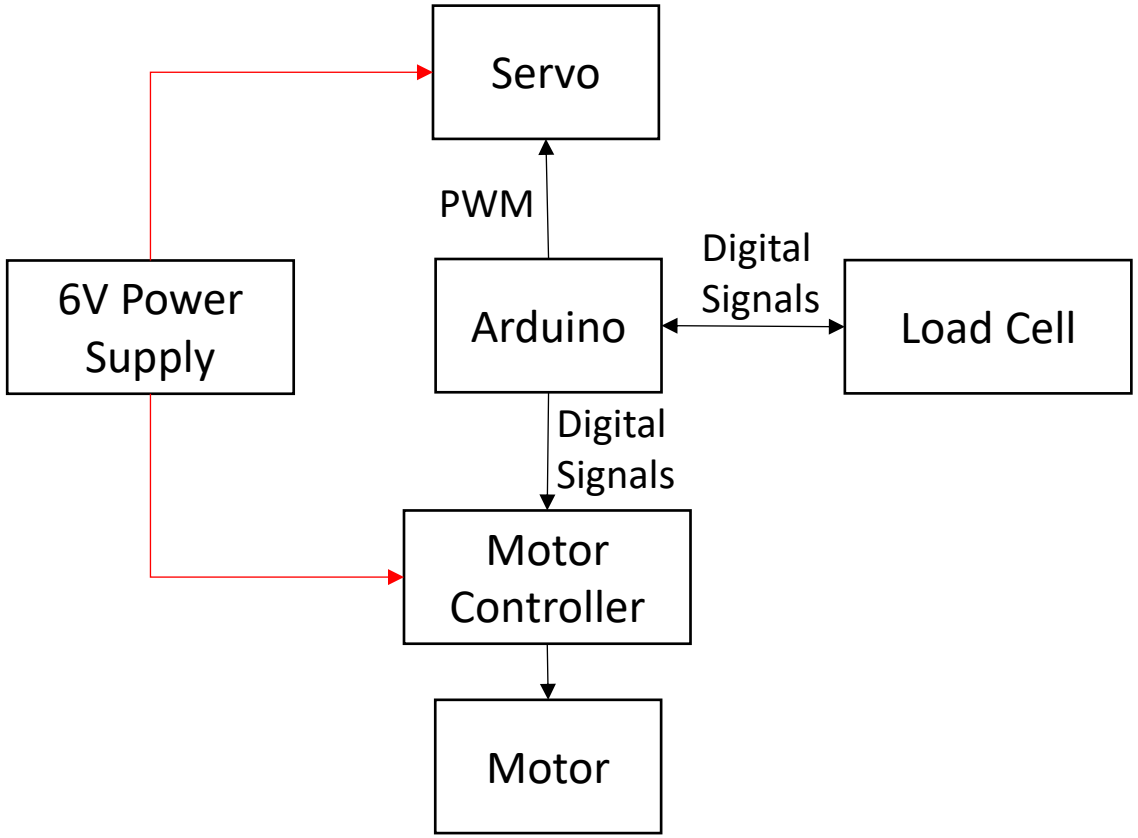
What's missing?



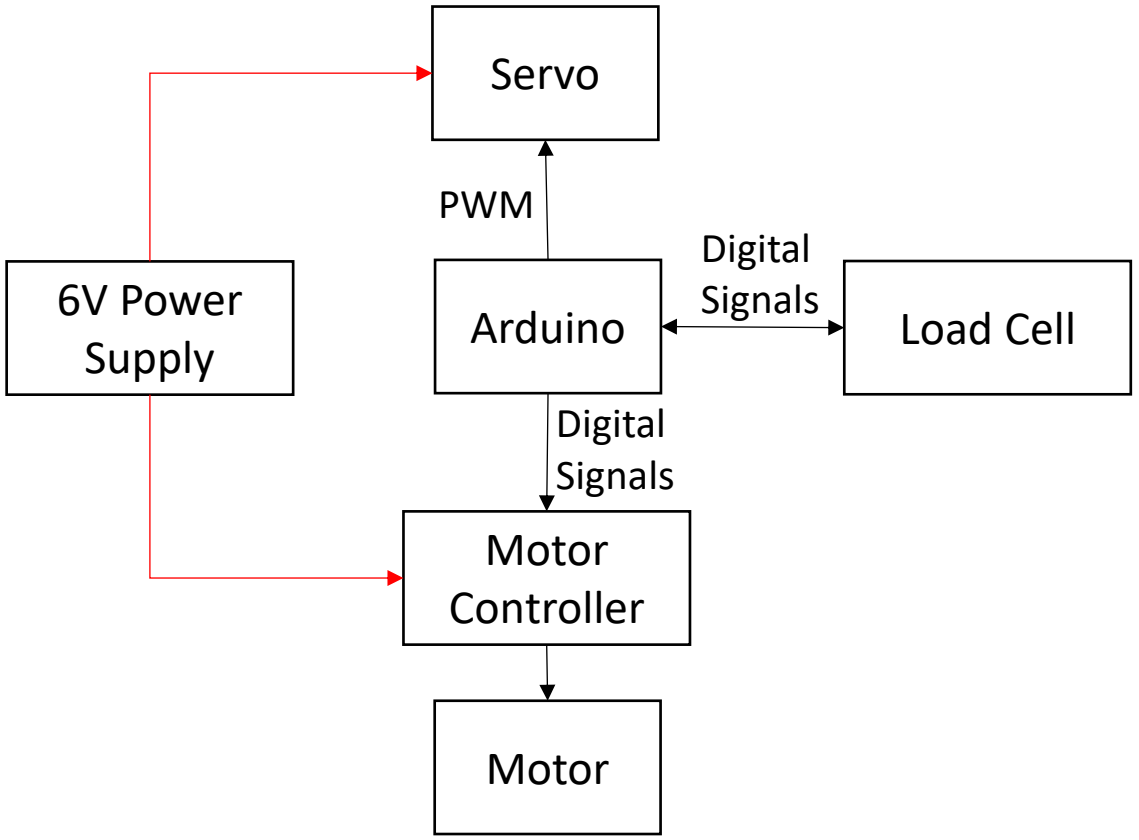
System Diagrams

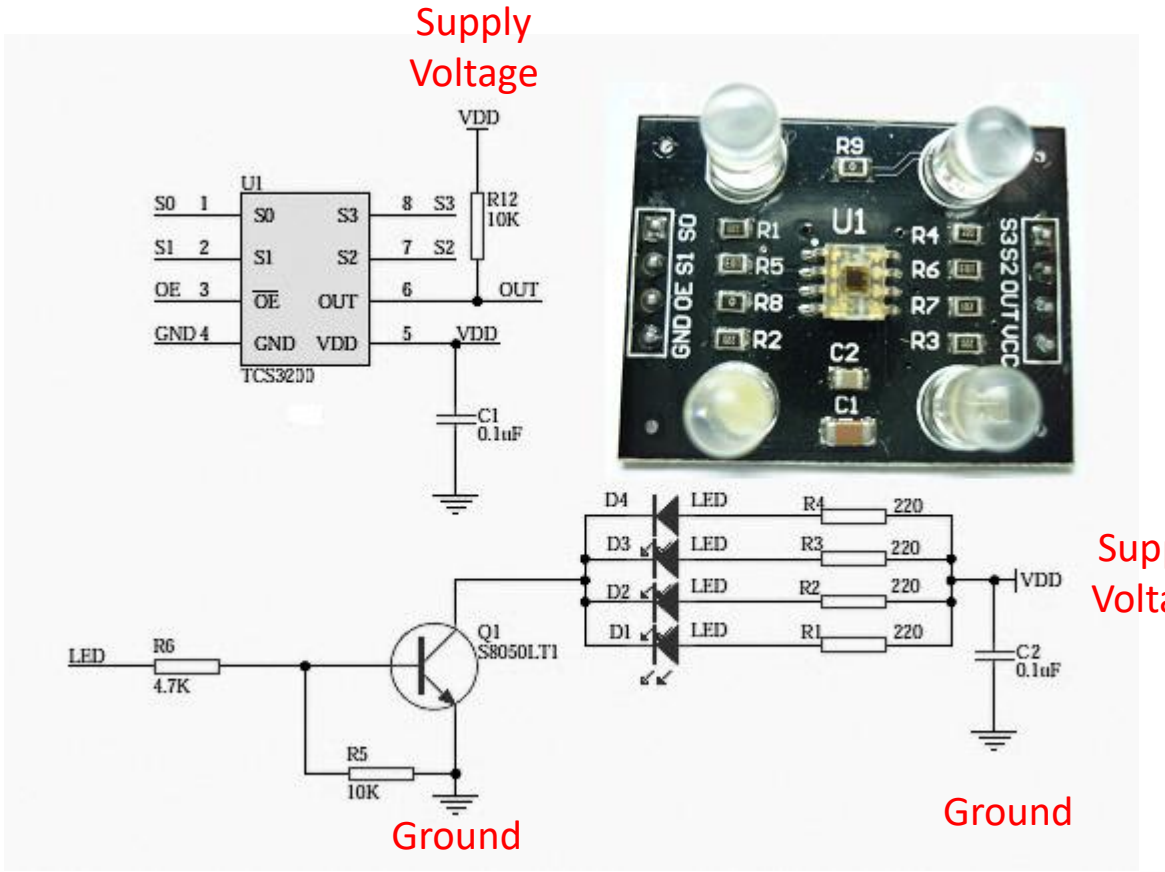
For a robot gripper with following what would our system diagram look like?

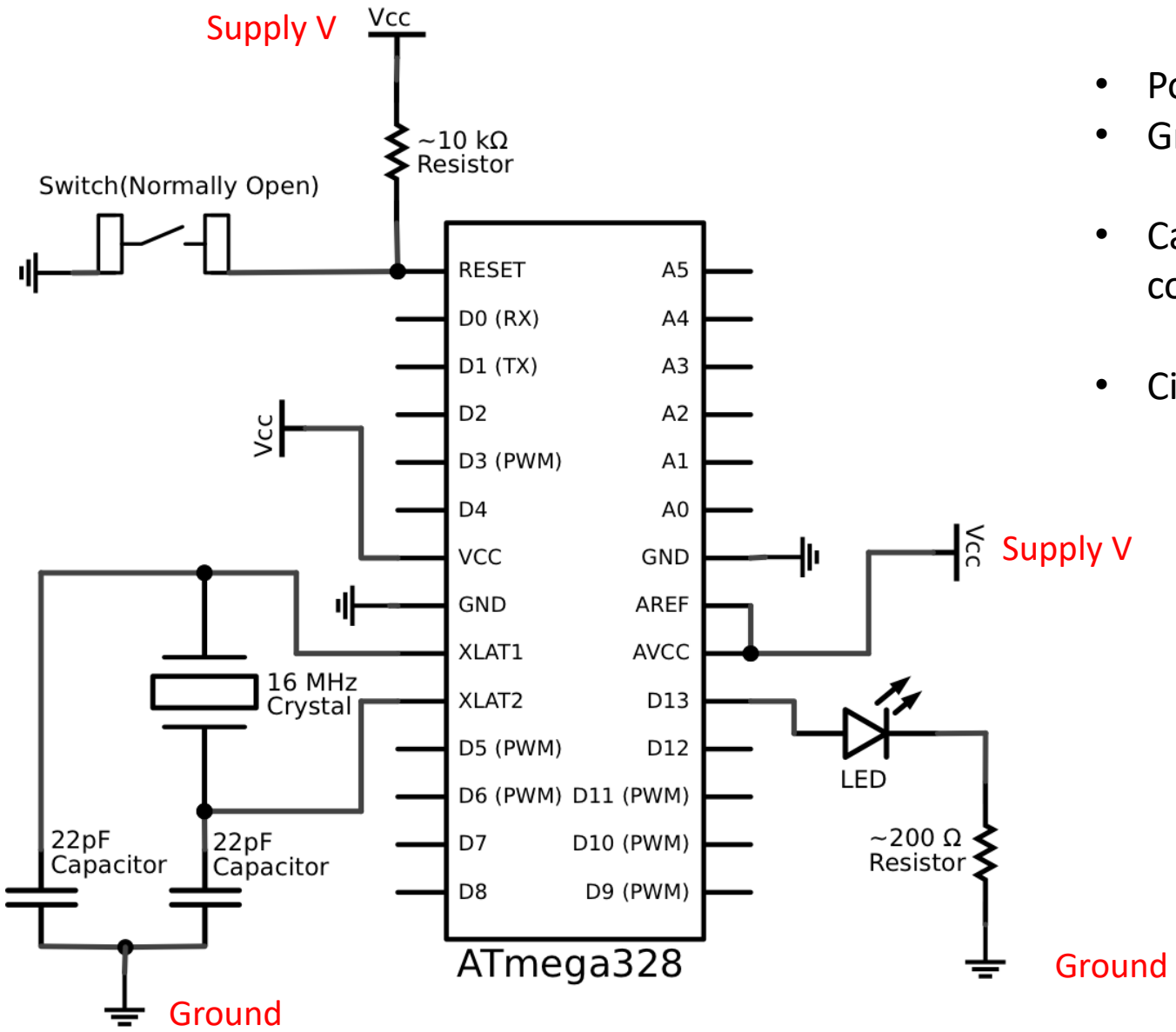
Servo, Motor, Motor Controller, Microcontroller, Load Cell



Electronics Schematics



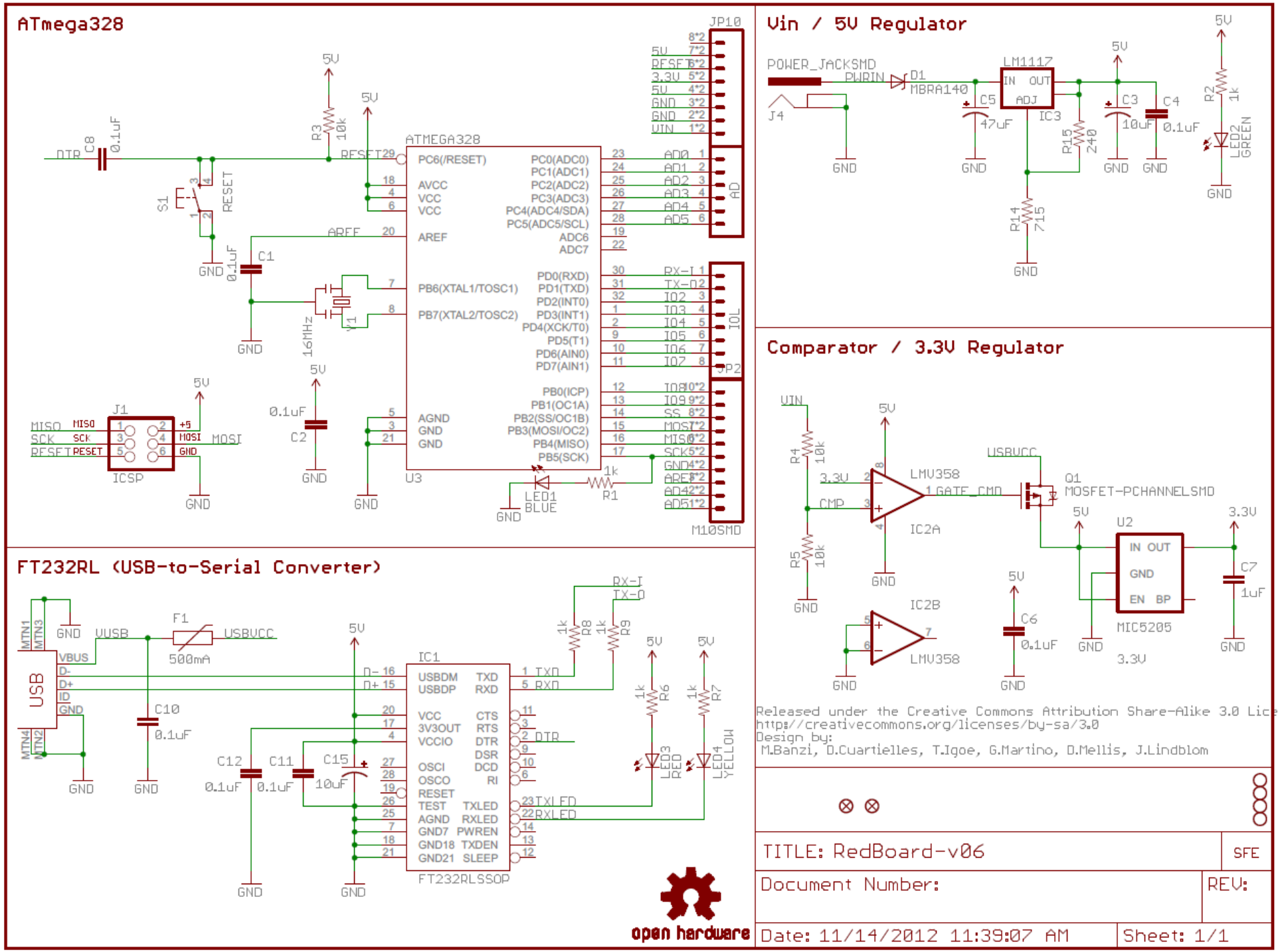




- Power Rails
- Ground Rails

- Can separate into different circuit components with common GND + VCC connections

- Circuit Symbols


ATmega328
JP10
ATMEGA328
PC6(/RESET)
PC0(ADC0)
PC1(ADC1)
PC2(ADC2)
PC3(ADC3)
PC4(ADC4/SDA)
PC5(ADC5/SCL)
ADC6
ADC7
PB6(XTAL1/TOSC1)
PB7(XTAL2/TOSC2)
PD0(RXD)
PD1(TXD)
PD2(INT0)
PD3(INT1)
PD4(XCK/T0)
PD5(T1)
PD6(AIN0)
PD7(AIN1)
PB0(ICP)
PB1(OC1A)
PB2(SS/OC1B)
PB3(MOSI/OC2)
PB4(MISO)
PB5(SCK)
AVCC
AREF
AGND
GND
U3
16MHz
Y1
RESET
ICSP
LED1
BLUE
M10SMD
Vin / 5V Regulator
POWER_JACKSMD
MBRA140
LM1117
IC3
Comparator / 3.3V Regulator
LMV358
IC2A
IC2B
MIC5205
Q1
MOSFET-PCHANNELSMD
FT232RL (USB-to-Serial Converter)
IC1
FT232RLSSOP
USB
LED3
RED
LED4
YELLOW
Released under the Creative Commons Attribution Share-Alike 3.0 Lic
https://creativecommons.org/licenses/by-sa/3.0
Design by:
M.Banzi, D.Cuartielles, T.Igoe, G.Martino, D.Mellis, J.Lindblom
TITLE: RedBoard-v06
SFE
Document Number:
REV:
Date: 11/14/2012 11:39:07 AM
Sheet: 1/1

PRODUCT & E

Layouts

- Breadboard Layouts
- Veroboard Layouts
- PCB Layouts

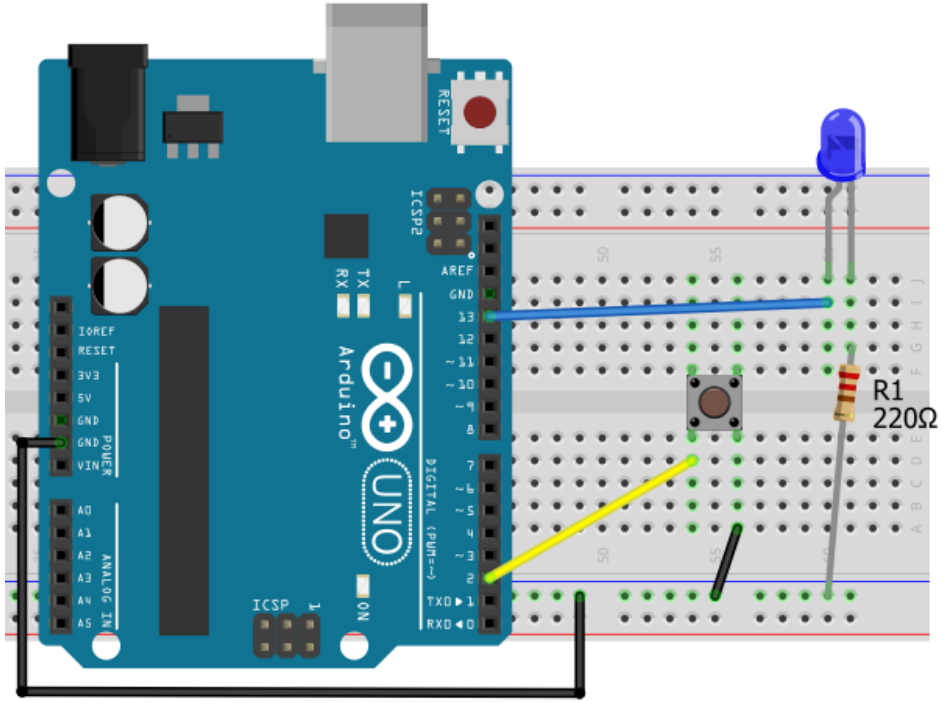
Link together

Circuit Diagram → Footprint of Components → Optimized Circuit

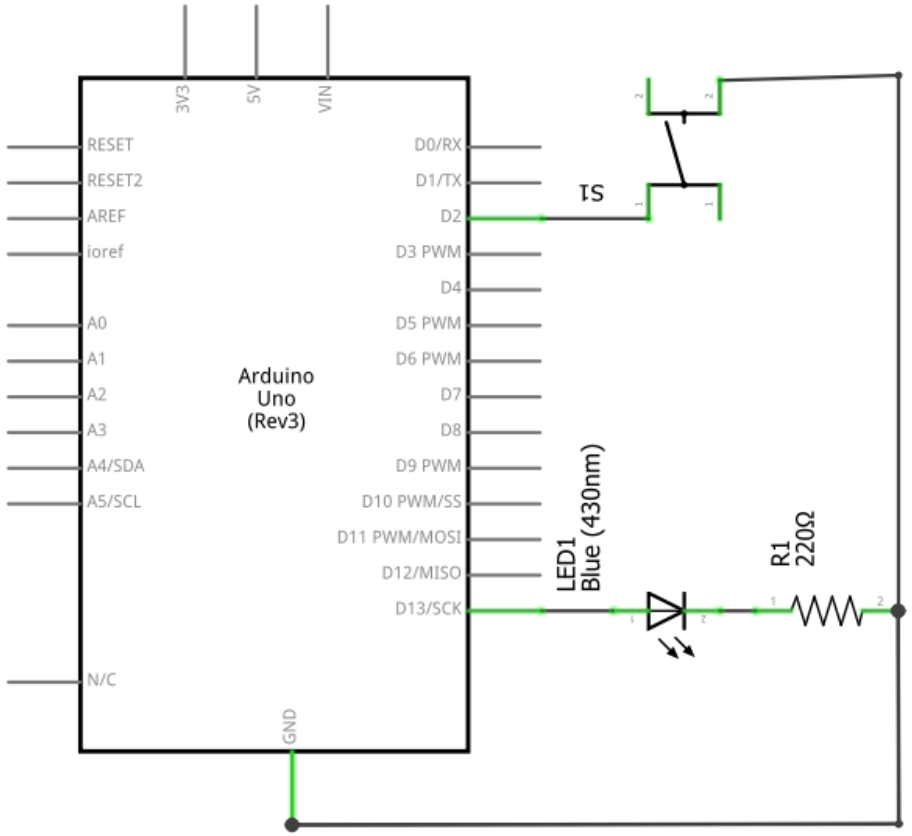
Layouts

Breadboard Layout

Breadboard View

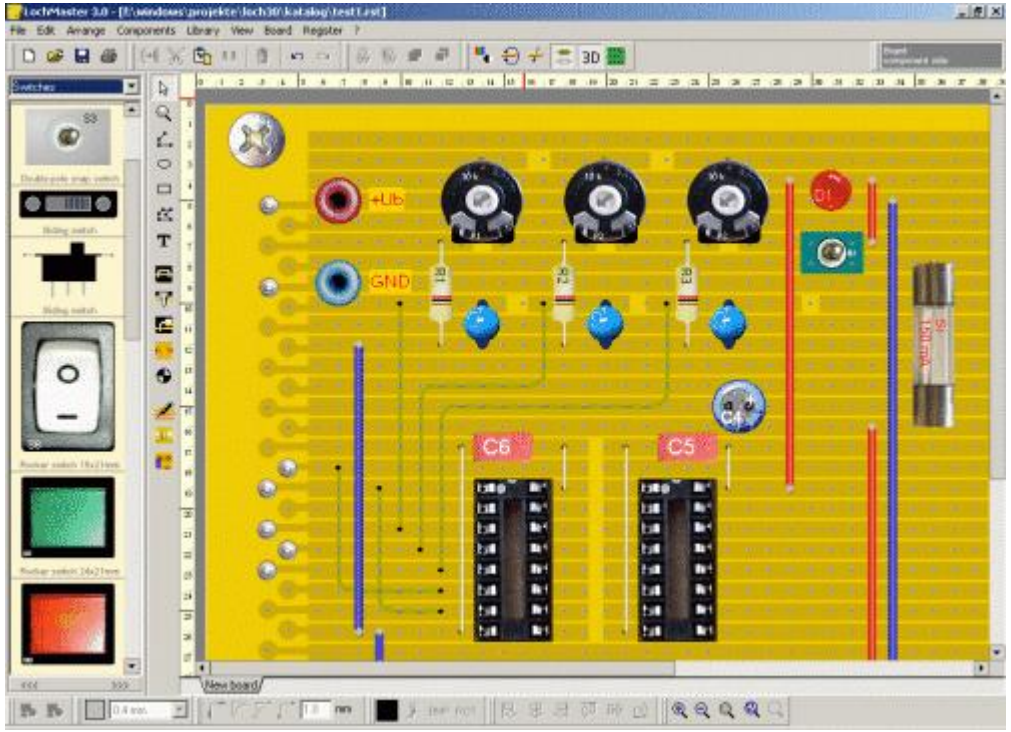


Schematic View



Layouts

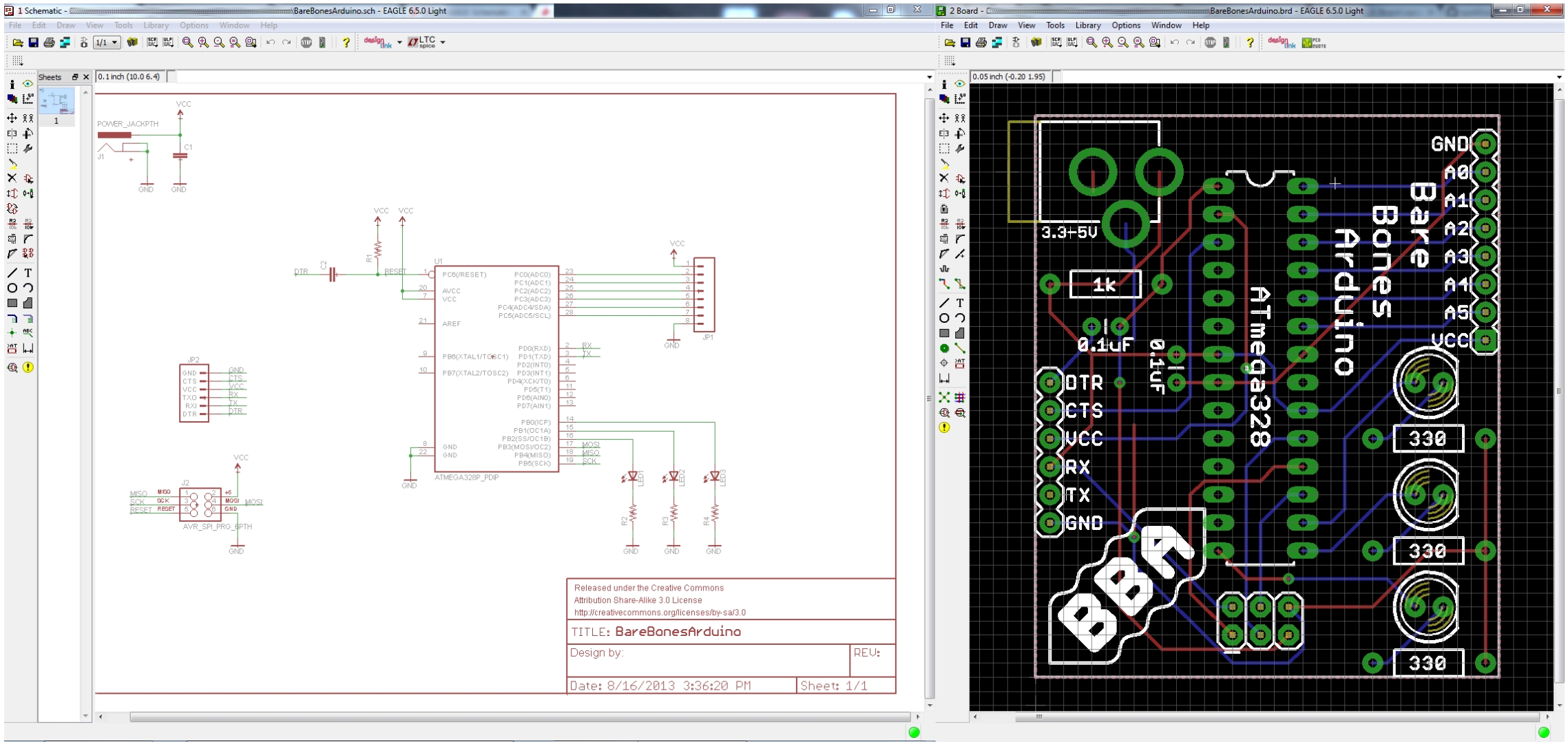
Veroboard Layout



- Footprint of different components
- Cutting/strips of wire
- Placement of components

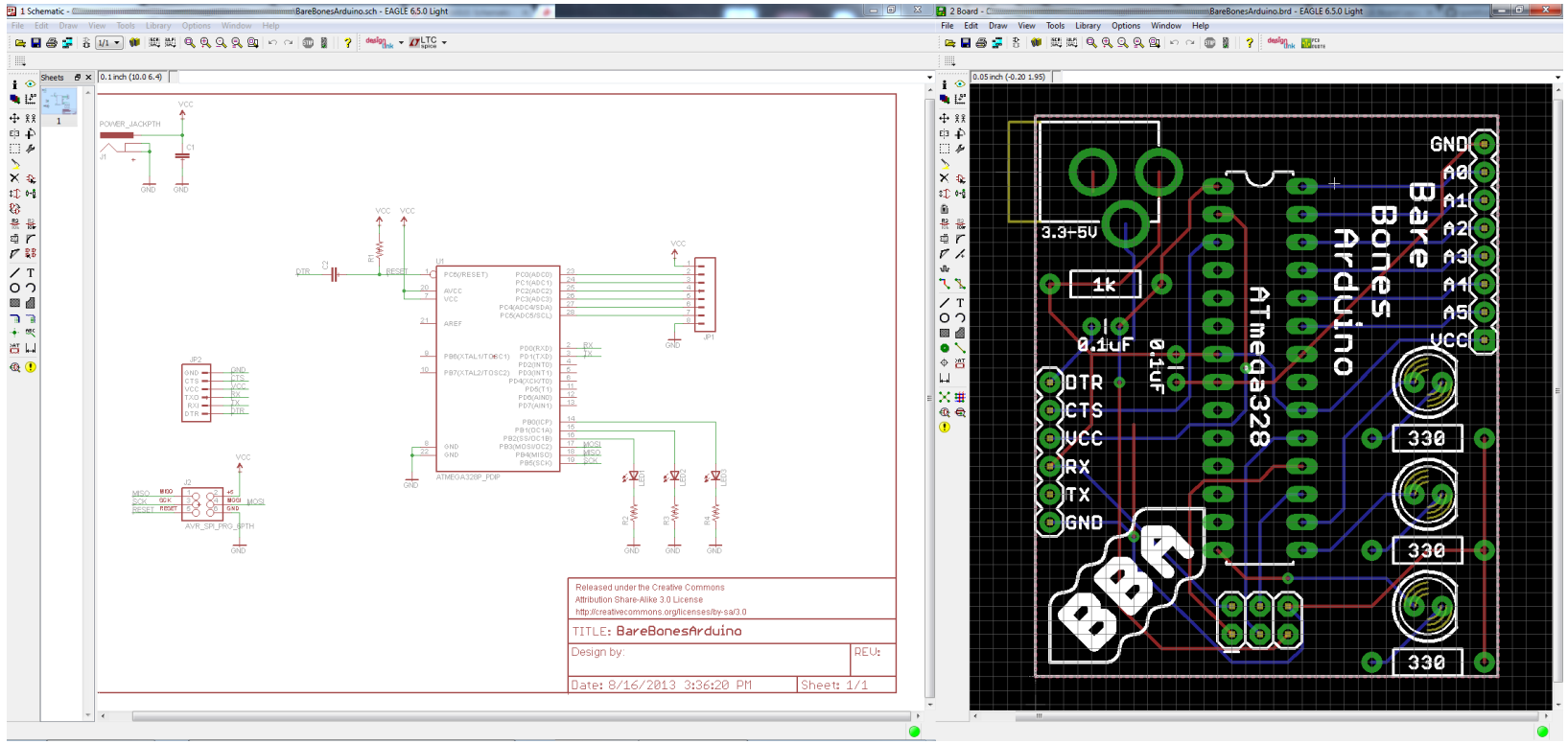
Layouts

PCB Layout



Layouts

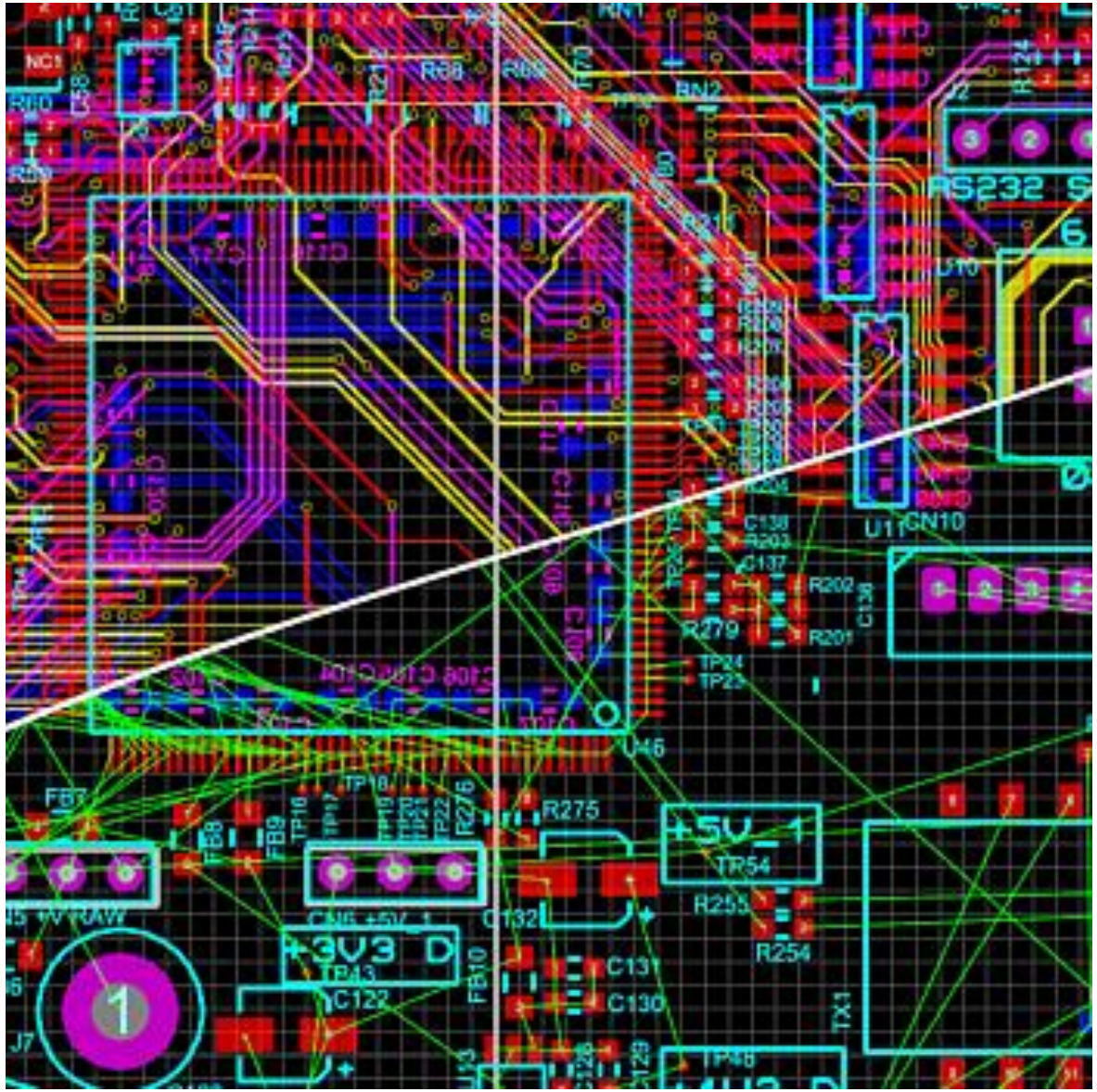
PCB Layout



- Footprint
- Manufacturing capabilities
- Routing of layers
- Ground plane

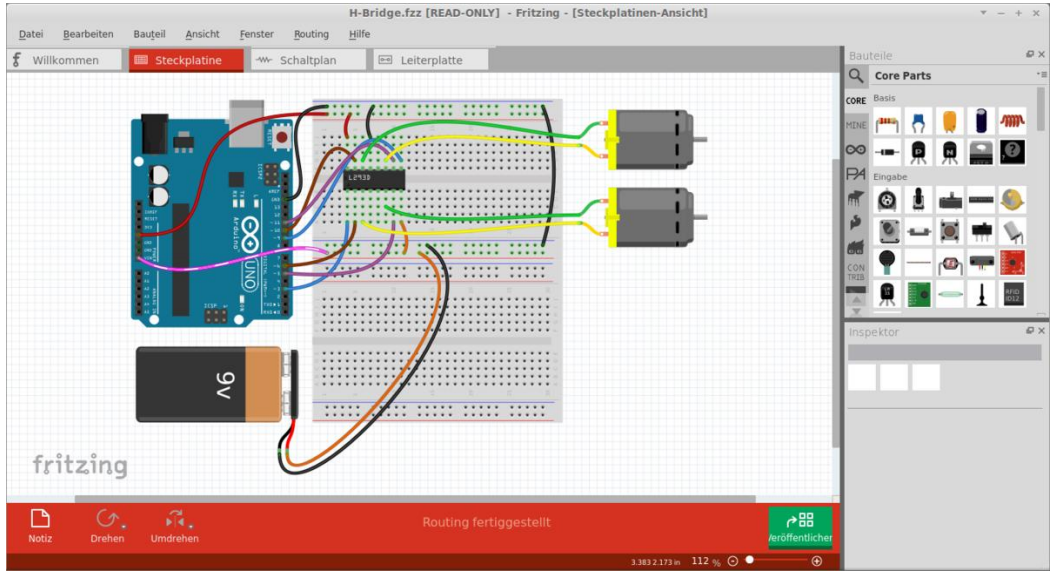
Layouts

PCB Layout



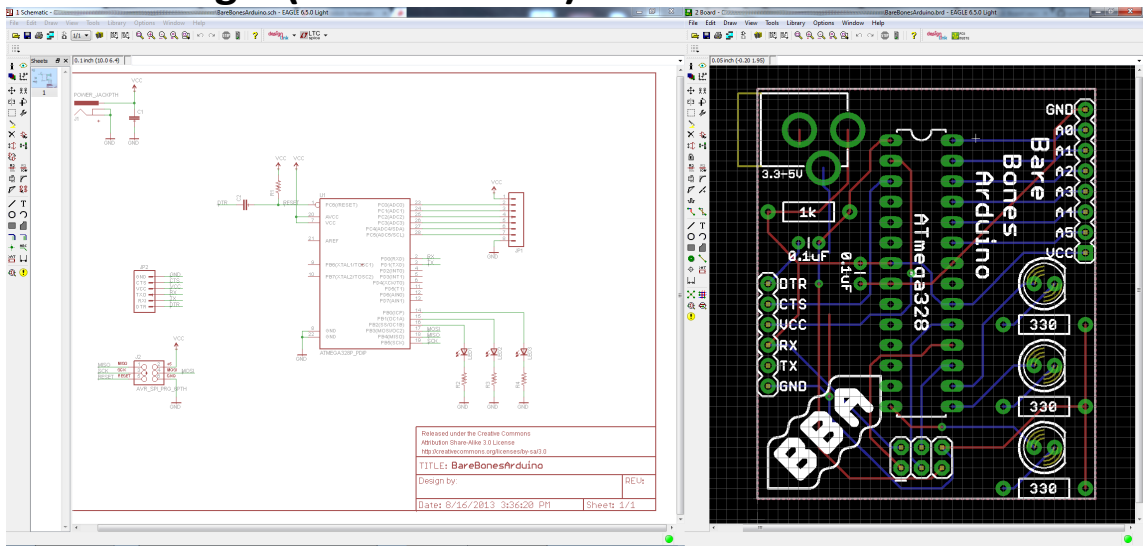
Electronics Diagrams: Available Tools

Fritzing: Online Protoyping Electronics Tool



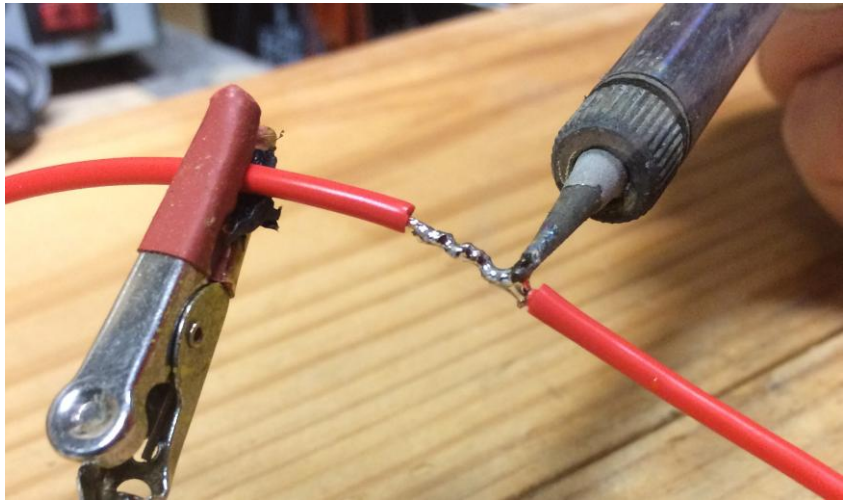
Circuit diagram, layout, PCB

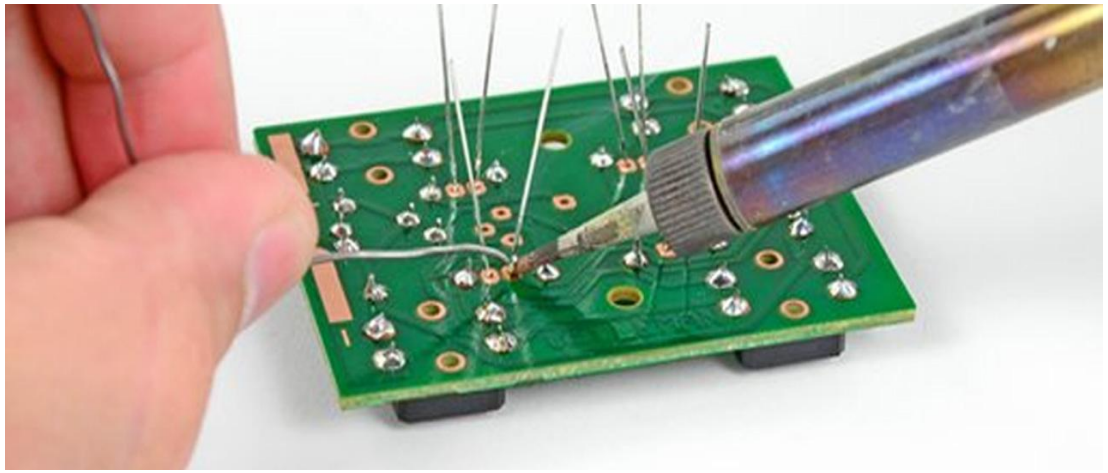
Eagle (CAD for PCBS)



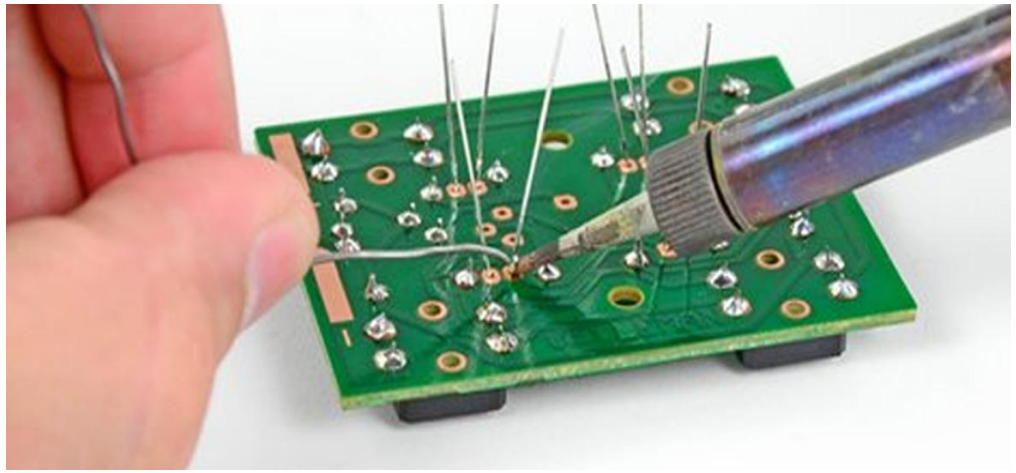
Schematic, database of parts/footprints, layout tools.

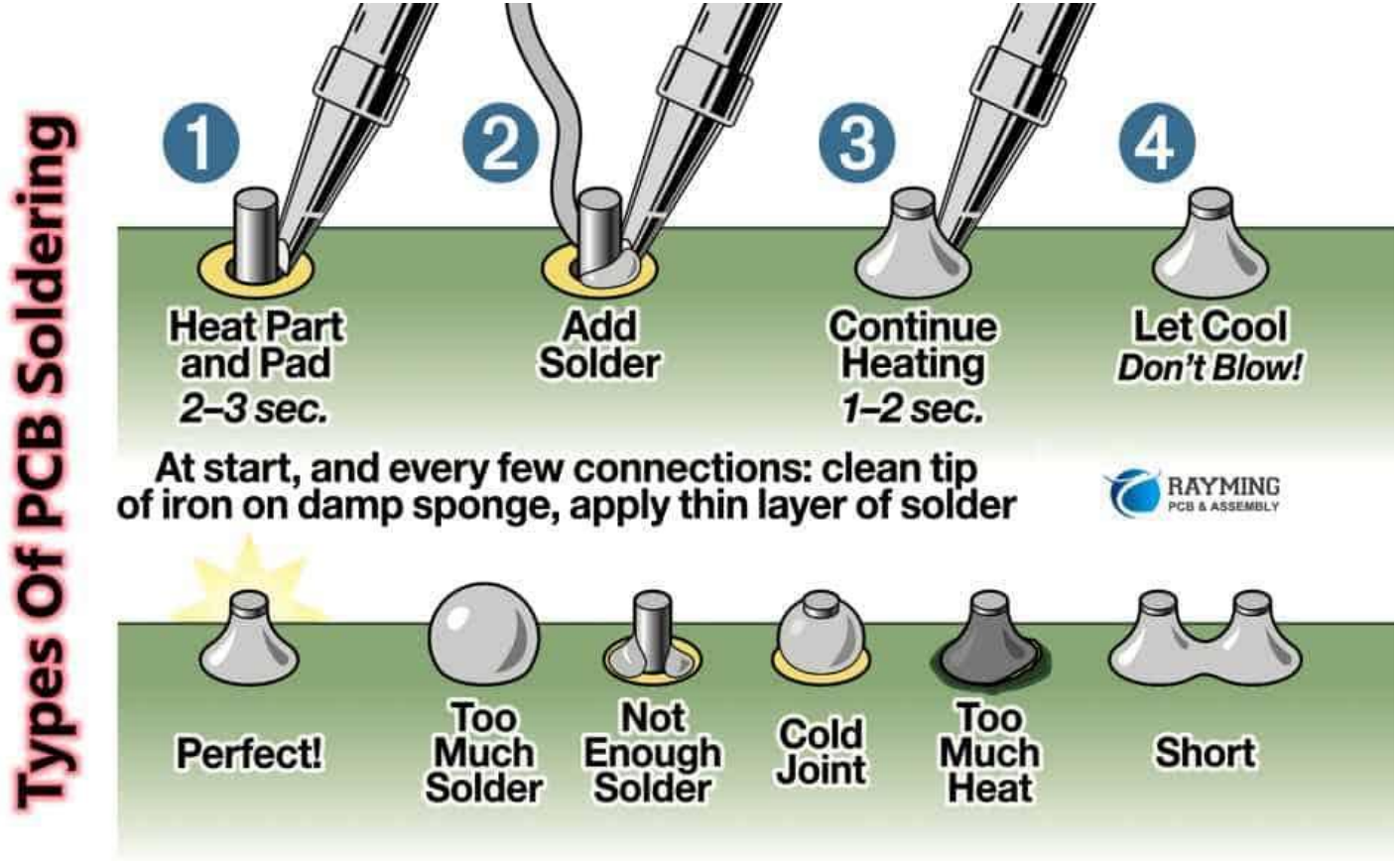
Soldering!



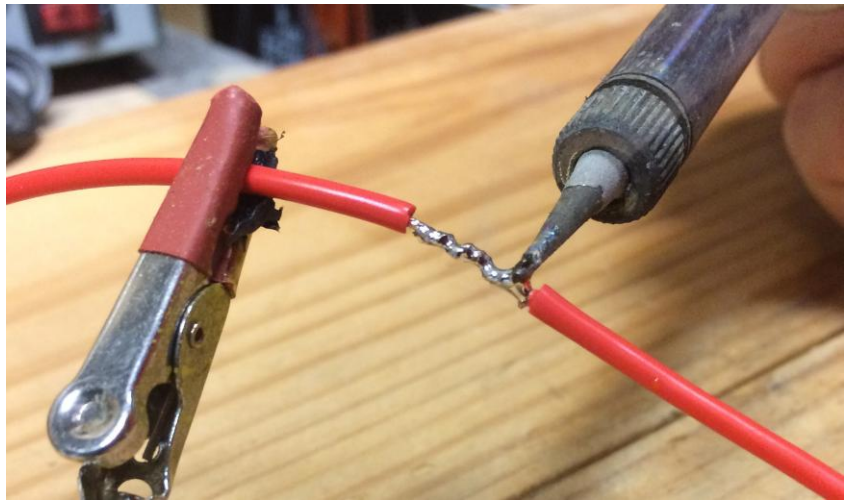


Soldering!




Types Of PCB Soldering
1
Heat Part and Pad
2–3 sec.
2
Add Solder
3
Continue Heating
1–2 sec.
4
Let Cool
Don't Blow!
At start, and every few connections: clean tip of iron on damp sponge, apply thin layer of solder
RAYMING
PCB & ASSEMBLY
Perfect!
Too Much Solder
Not Enough Solder
Cold Joint
Too Much Heat
Short

Soldering!



https://www.youtube.com/watch?v=-qk-ulz05J8&ab_channel=HowDoYou%3FDIY

Representing Flow/Decision Making

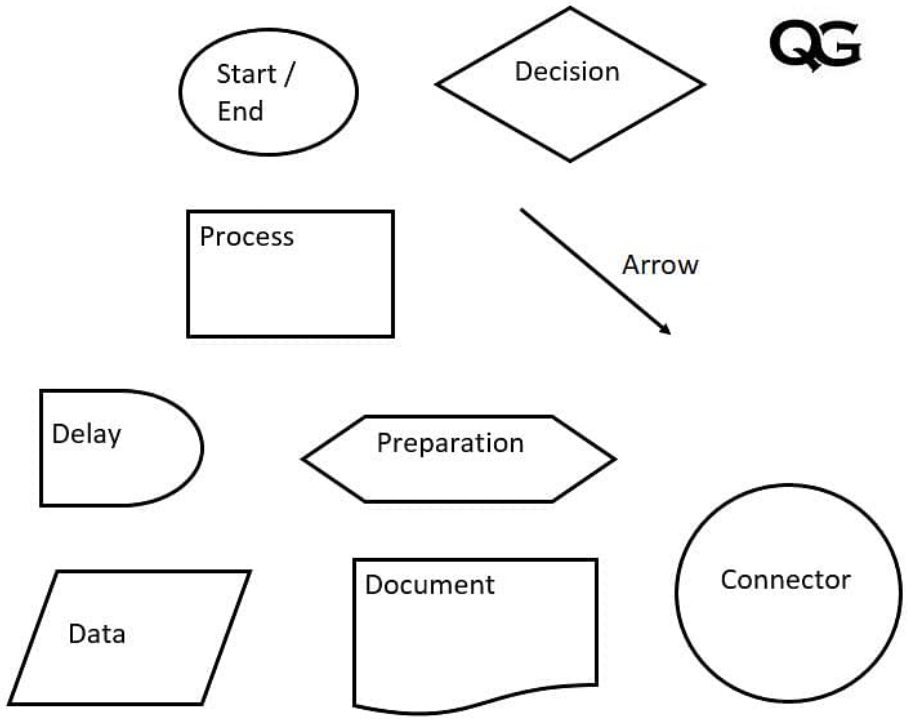
Code is not a good means of communication

How could we communicate decisions?

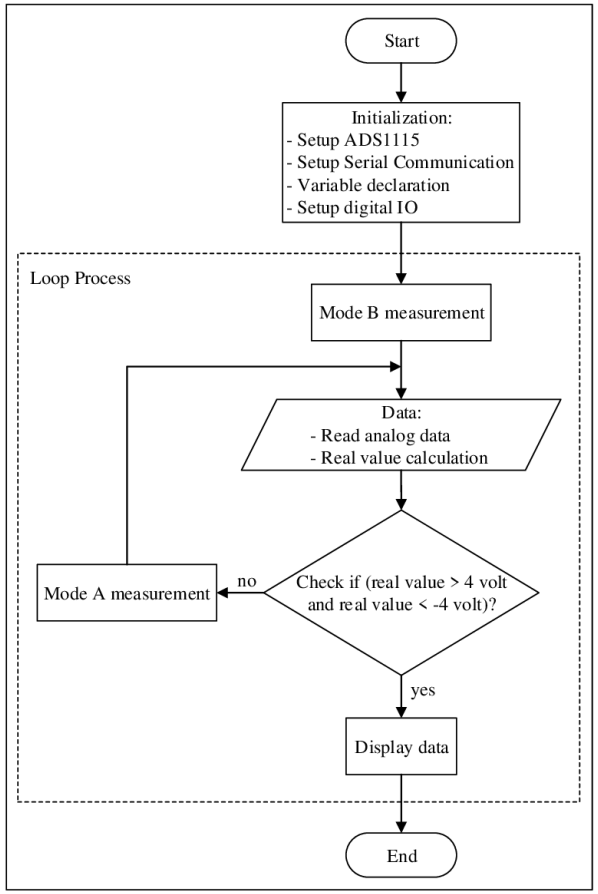
Representing Flow/Decision Making

Flow charts

Standard Symbols



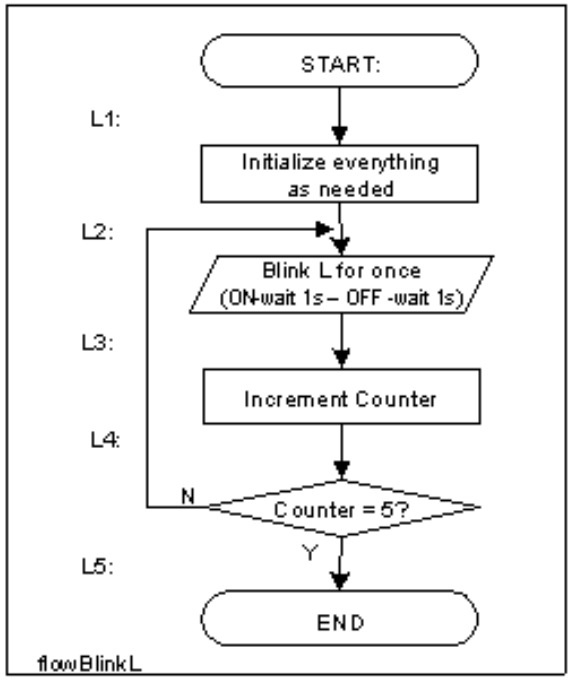
Example flow chart



Representing Flow/Decision Making

Flow charts

What does this flow chart do?



Representing Flow/Decision Making

Pseudo Code

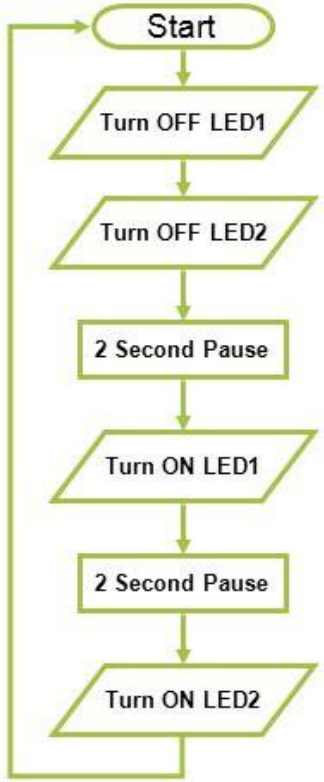
Looping Flow Example

Pseudo-Code:

Start of program

- Turn off LED 1
- Turn off LED 2
- Pause for 2 seconds
- Light LED 1
- Pause for 2 seconds
- Light LED 2
- Go back to start

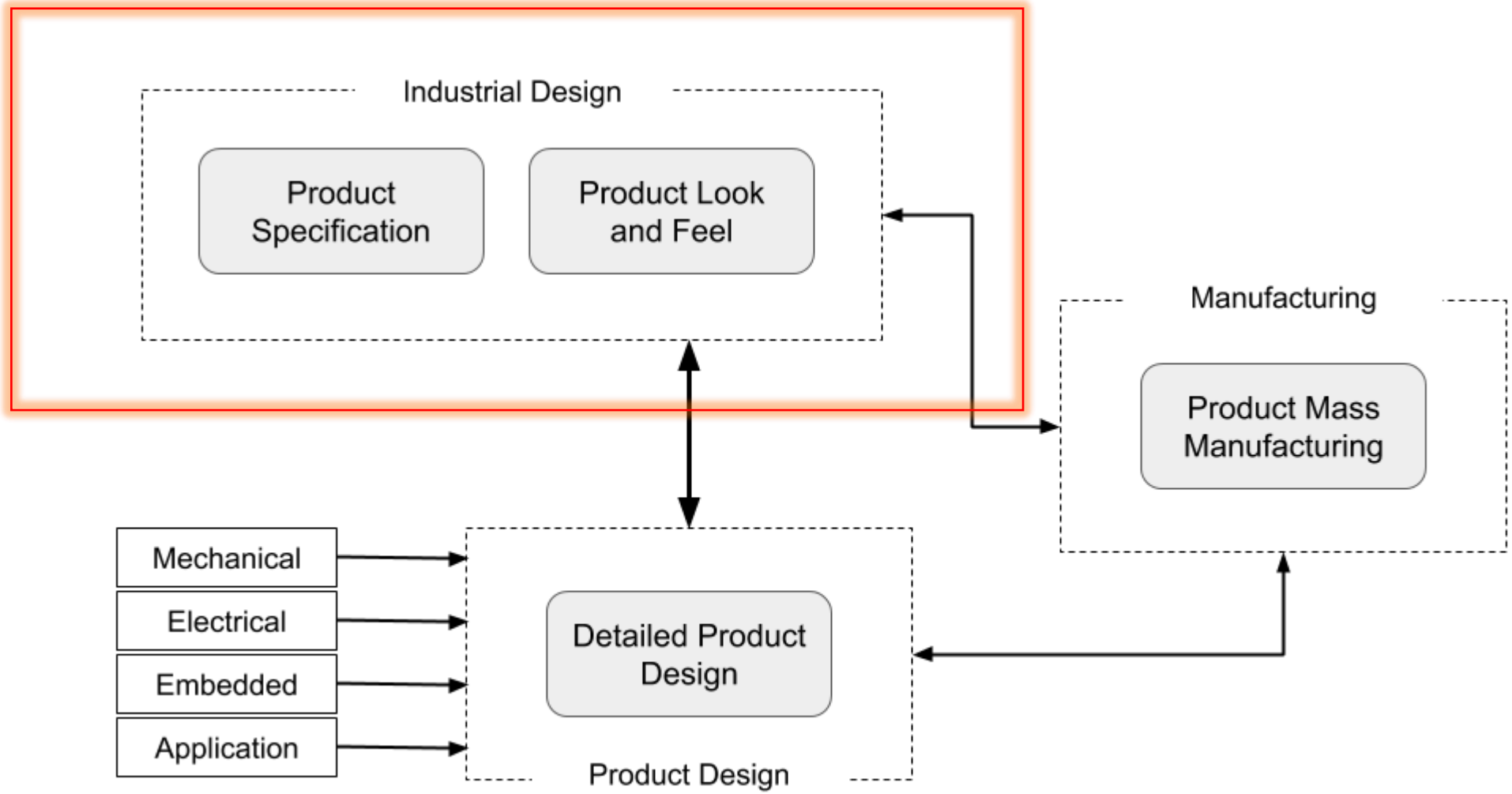
Flowchart:



- Finalized concept
- Finalized key engineering concept
- Demonstrated proof-of concept
- Work-like prototype
- Communicated concepts (drawings)

What next?

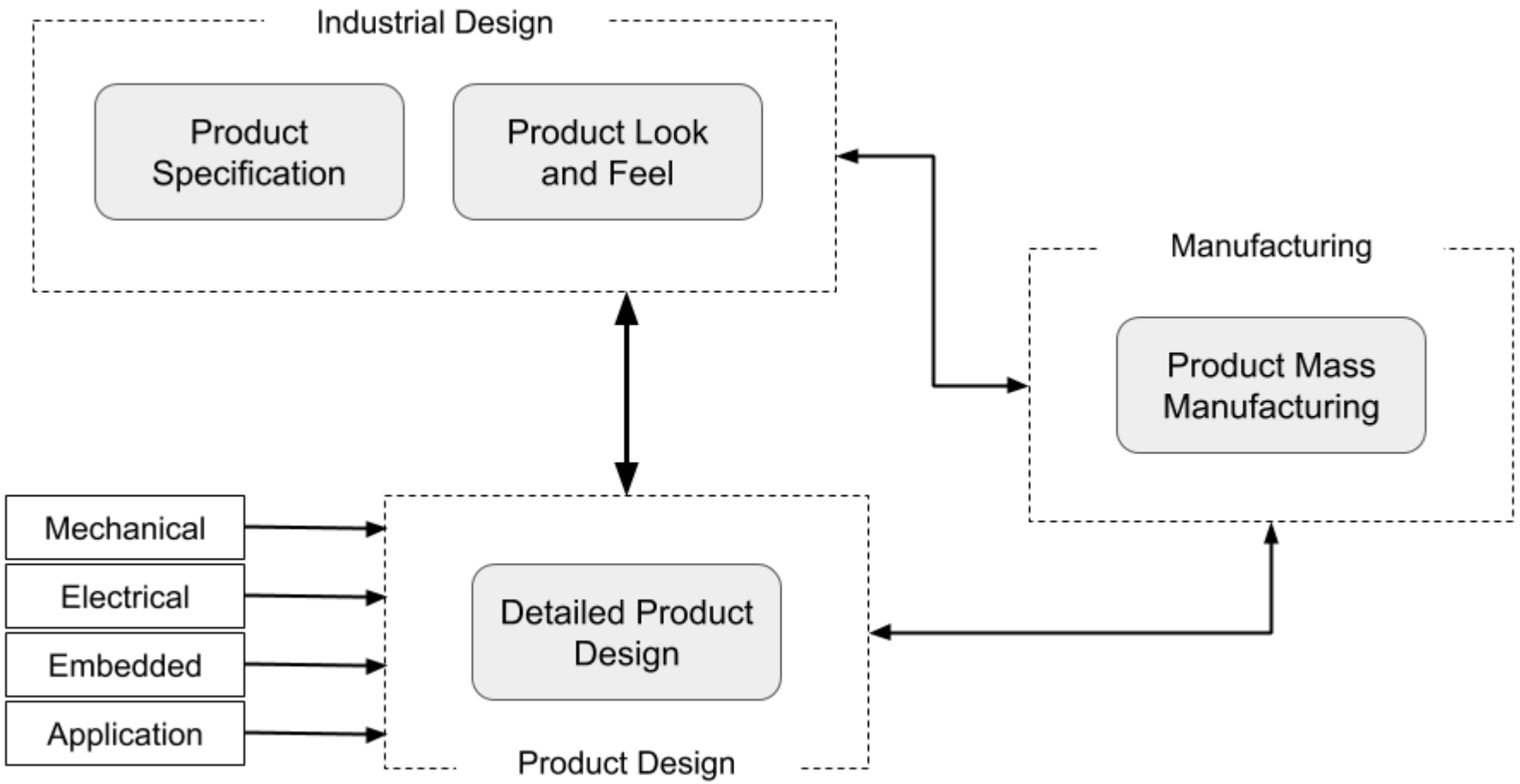
1) Industrial Design
2) Design for Manufacture


Industrial Design
Product Specification
Product Look and Feel
Manufacturing
Product Mass Manufacturing
Mechanical
Electrical
Embedded
Application
Detailed Product Design
Product Design

What is Industrial Design?

“(...) the professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer.”

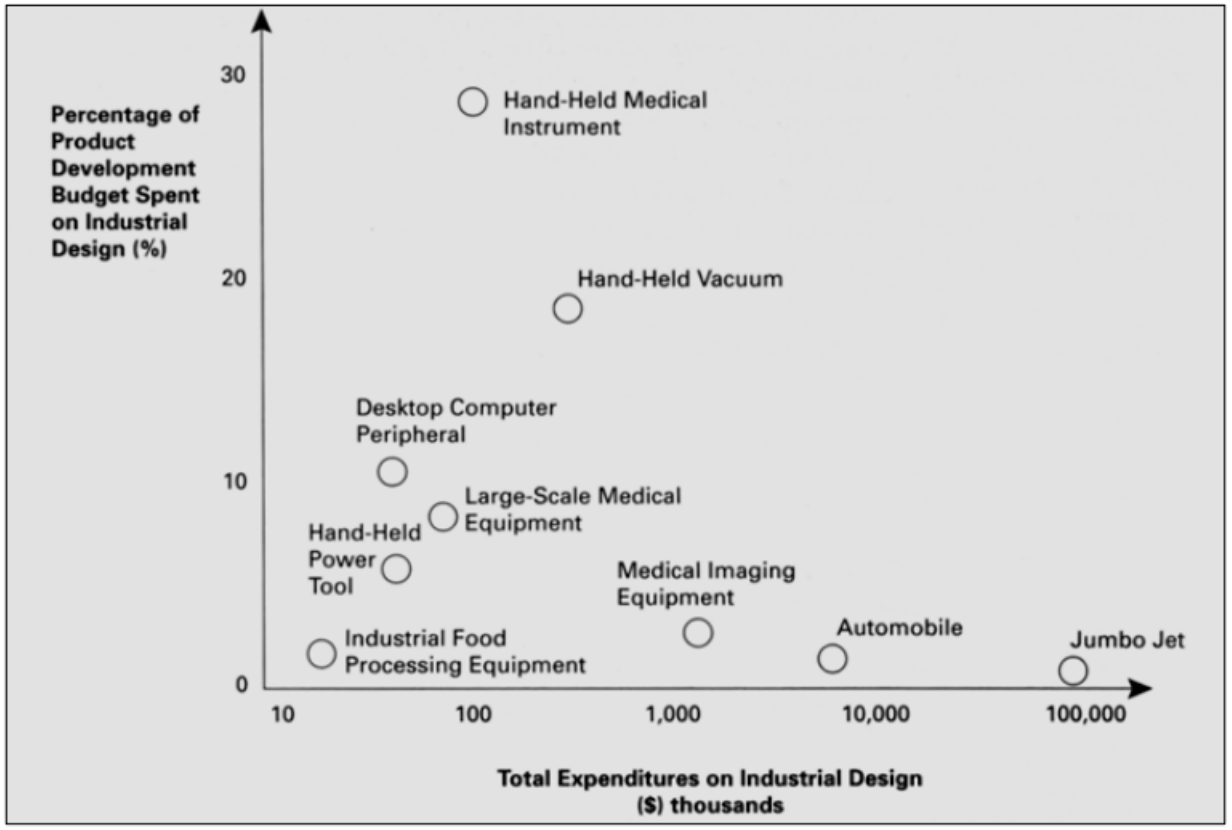
Industrial Designers Society of America


Industrial Design
Product Specification
Product Look and Feel
Manufacturing
Product Mass Manufacturing
Mechanical
Electrical
Embedded
Application
Detailed Product Design
Product Design

5 Goals of Industrial Design

- Utility
- Appearance
- Ease of maintenance
- Low costs
- Communication

How important is industrial design?

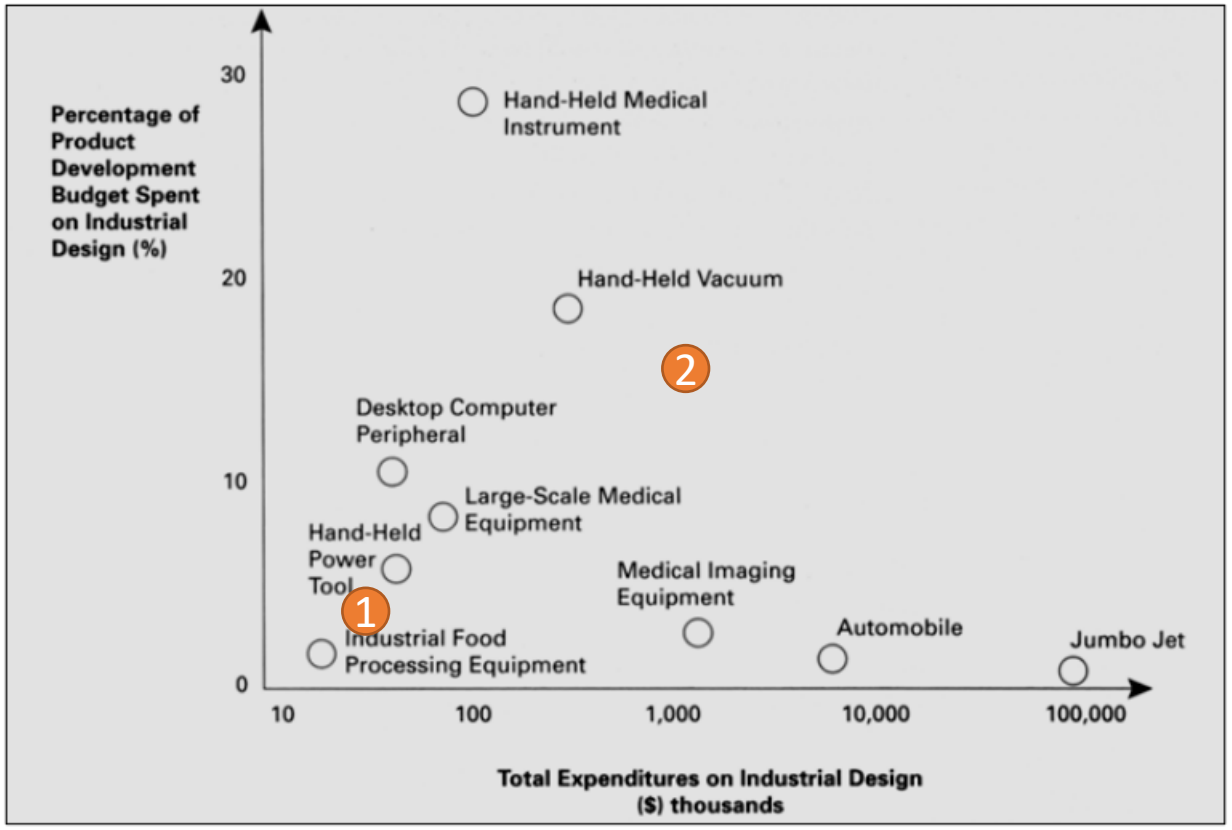


Where would you put:

1. Robot gripper for item handling
2. Mobile Phone

...varies with task

How important is industrial design?



Where would you put:

1. Robot gripper for item handling in factory
2. Mobile Phone

...varies with task

How important is industrial design?

Ergonomic needs

– How important is ease of use?
– How important is ease of maintenance?
– How many user interactions are required?
– How novel are the user interaction needs?
– What are the safety issues?

Aesthetic needs

– Is visual differentiation required?
– How important are pride of ownership, image and fashion?
– Will an aesthetic product motivate the team?

Needs	Level of Importance	Explanation of Rating
	Low Medium High	
Ergonomics		
Ease of use		Critical for a portable telephone since it may be used frequently, may be needed in emergency situations, and can be operated by motorists while driving. The product's function must be communicated through its design.
Ease of maintenance		As with many integrated electronics products there is very little maintenance required.
Quantity of user interactions		There are many important user interactions such as: changing the battery, dialing, programming the features, sending and receiving calls.
Aesthetics		
Product differentiation		There were hundreds of models of cellular pones on the market when the StarTAC was introduced. Its appearance (including its size and shape) was essential for differentiation.
Pride of ownership, fashion, or image		The StarTAC was intended to be a highly visible product used by people for business and personal communication in public areas. It had to be physically attractive for everyday use.
Team motivation		The StarTAC's novel form turned out to be an important inspiration to the development team and selling point for senior management.

StarTAC

The First Flip phone

The Impact of ID…

Is ID worth the investment?

- Direct cost
- Manufacturing cost
- Time cost

How does ID establish a corporate identity?

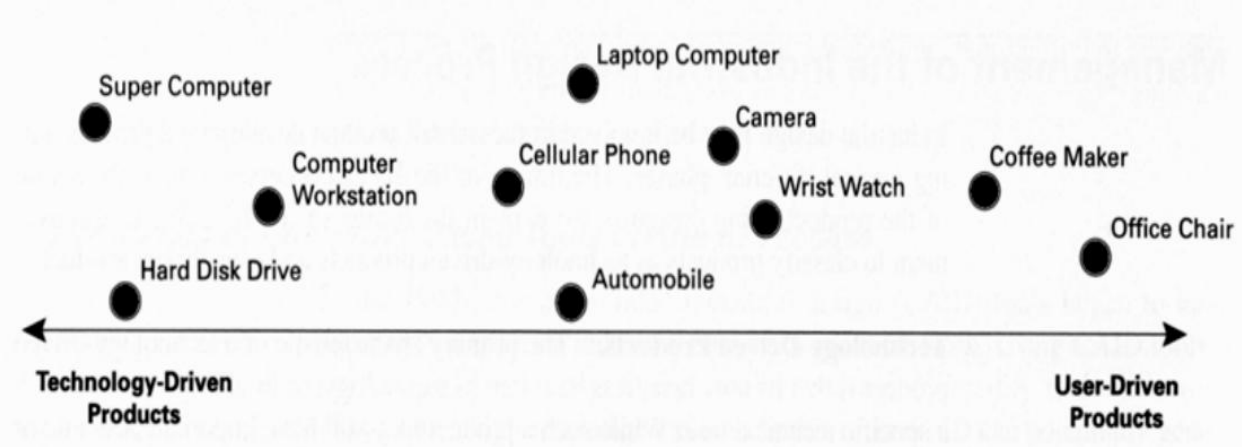
– Apple Computer, Inc.
– Rolex Watch Co.
– Braun AG
– Bang & Olufsen
– Motorola, Inc.

Iconic Examples of Industrial Design

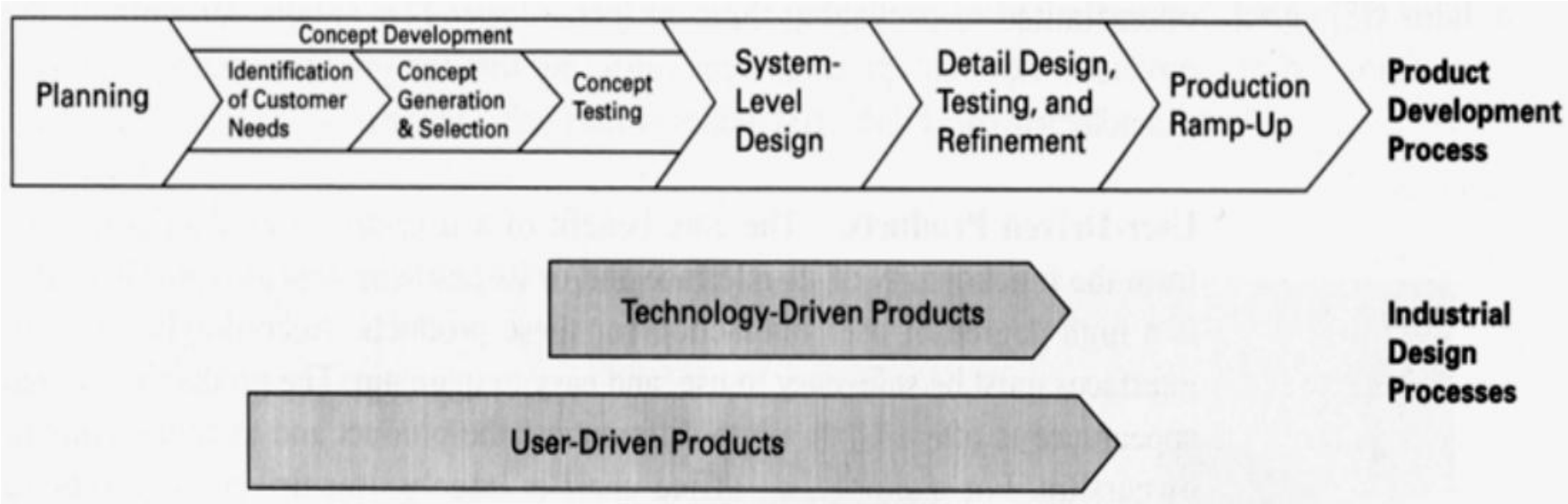
Ergonomics & Aesthetics help make these products stand out

Management of ID Process

- Technology-driven products
- User-driven products



Management of ID Process



- Can have pure product development or industrial design
- Most-likely blend and combine

Product Development Activity	Type of Product	
	Technology-Driven	**User-Driven**
Identification of Customer Needs	ID typically has no involvement	ID works closely with marketing to identify customer needs. Industrial designers participate in focus groups or one-on-one customer interviews
Concept Generation and Selection	ID works with marketing and engineering to assure that human factors and user-interface issues are addressed. Safety and maintenance issues are often of primary importance	ID generates multiple concepts according to the industrial design process flow described earlier
Concept Testing	ID helps engineering to create prototypes, which are shown to customers for feedback	ID leads in the creation of models to be tested with customers by marketing
System-Level Design	ID has typically little involvement	ID narrows down the concepts and refines the most promising approaches
Detail Design, Testing and Refinement	ID is responsible for packaging the product once most of the engineering details have been addressed. ID receives product specifications and constraints from enginering and marketing	ID selects a final concept, then coordinates with engineering, manufacturing and marketing to finalize the design

Assessing the quality of ID

Metrics for assessing ID:

- Quality of the user interfaces
- Emotional appeal
- Ability to maintain and repair the product
- Appropriate use of resources
- Product differentiation

Can be subjective…
May not appeal to all

Assessing the quality of ID

Assessment Category	Level of Importance (Low / Medium / High)	Explanation of Rating
1. Quality of the User Interfaces		In general, the StarTAC is both easy to use and comfortable. For example: calls can be answered by simply opening the keypad cover, numbers can be easily dialed into the keypad, and the functions are readily accessible. The StarTAC's drawbacks include that the visual display can be difficult to interpret because it mixes upper- and lower-case alphabetic characters, and that some users inadvertently remove the battery when attempting to open the phone for the first time.
2. Emotional Appeal		The StarTAC has a high emotional appeal which stems from its sleek appearance and tiny size.
3. Ability to Maintain and Repair the Product		Although maintenance and repair are not of primary importance to the customer, the StarTAC rates high in this category. The battery can be removed and replaced easily. Customers can install various batteries depending on their preference for size, weight, and talk time.
4. Appropriate Use of Resources		The final design includes only those features that satisfy real customer needs. Materials were selected to satisfy manufacturing constraints, to withstand extreme environmental conditions, and to meet strict appearance criteria.
5. Product Differentiation		The StarTAC's appearance is clearly unique. It is easily identified when viewed in a public area or next to a competitor's product.

StarTAC

The First Flip phone

Summary

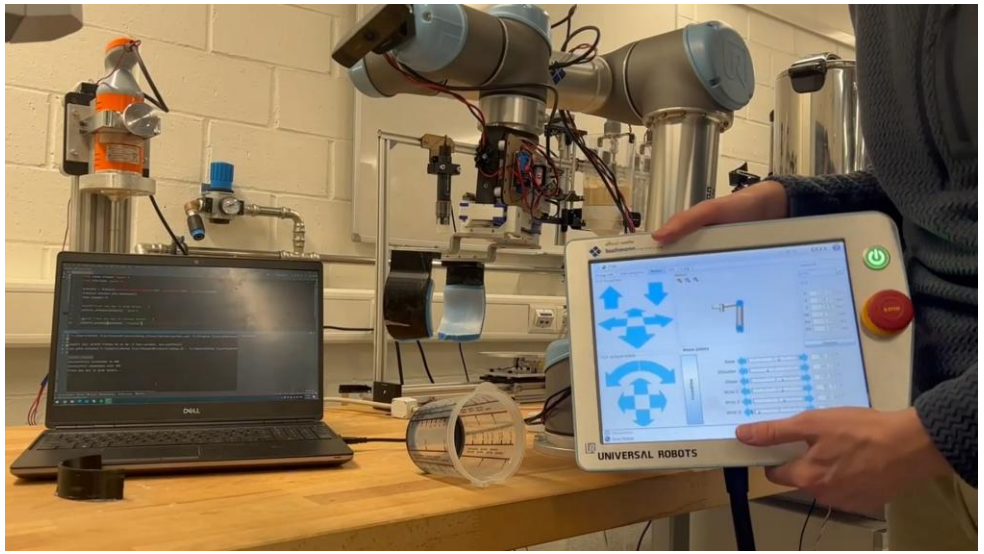
- The primary mission of ID is to design the aspects of a product that relate to the user: aesthetics and ergonomics
- Most products can benefit in some way or another from ID.
- When the success of a product relies more on technology, ID can be integrated into development process later.

Project

General Advice:

- Integrate and test early – this takes time
- Something is better than nothing
  - Taking some small scarifies in capabilities but getting a reliable system could be sensible
- Keep it simple (e.g. fewer actuators/sensors have fewer points of failure)
- Testing is super important

Controlling Program Flow

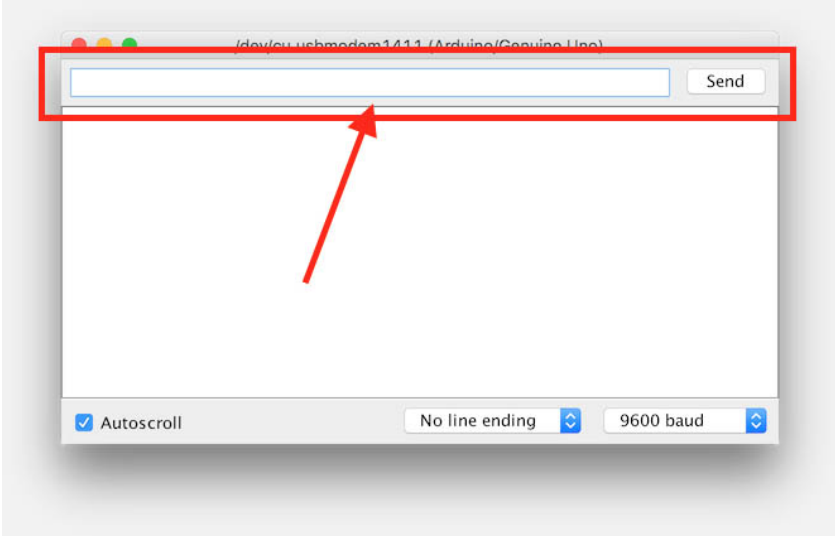


Trigger the different parts of the code

Use serial inputs to control the process flow on Arduino.

Wait for serial inputs

```
void setup() {
  Serial.begin(9600);

  Serial.println("1. Close");
  Serial.println("2. Sense");
  Serial.println("3. Open");
}

void loop() {
  Serial.println("Which process would you like to do ");

  while (Serial.available() == 0) {
  }

  int menuChoice = Serial.parseInt();

  switch (menuChoice) {
    case 1:
      // Gripper Close code
      Serial.println("Closing Gripper");
      break;

    case 2:
      // Sensing
      Serial.println("Object is xxxx");
      break;

    case 3:
      // Gripper Open
      Serial.println("Opening Gripper");
      break;


    default:
      Serial.println("Please choose a valid selection");
  }
}
```



Electronics

Generating more Male/Female connectors, or making them an arbitrary length…

DuPont Connector Kit…