



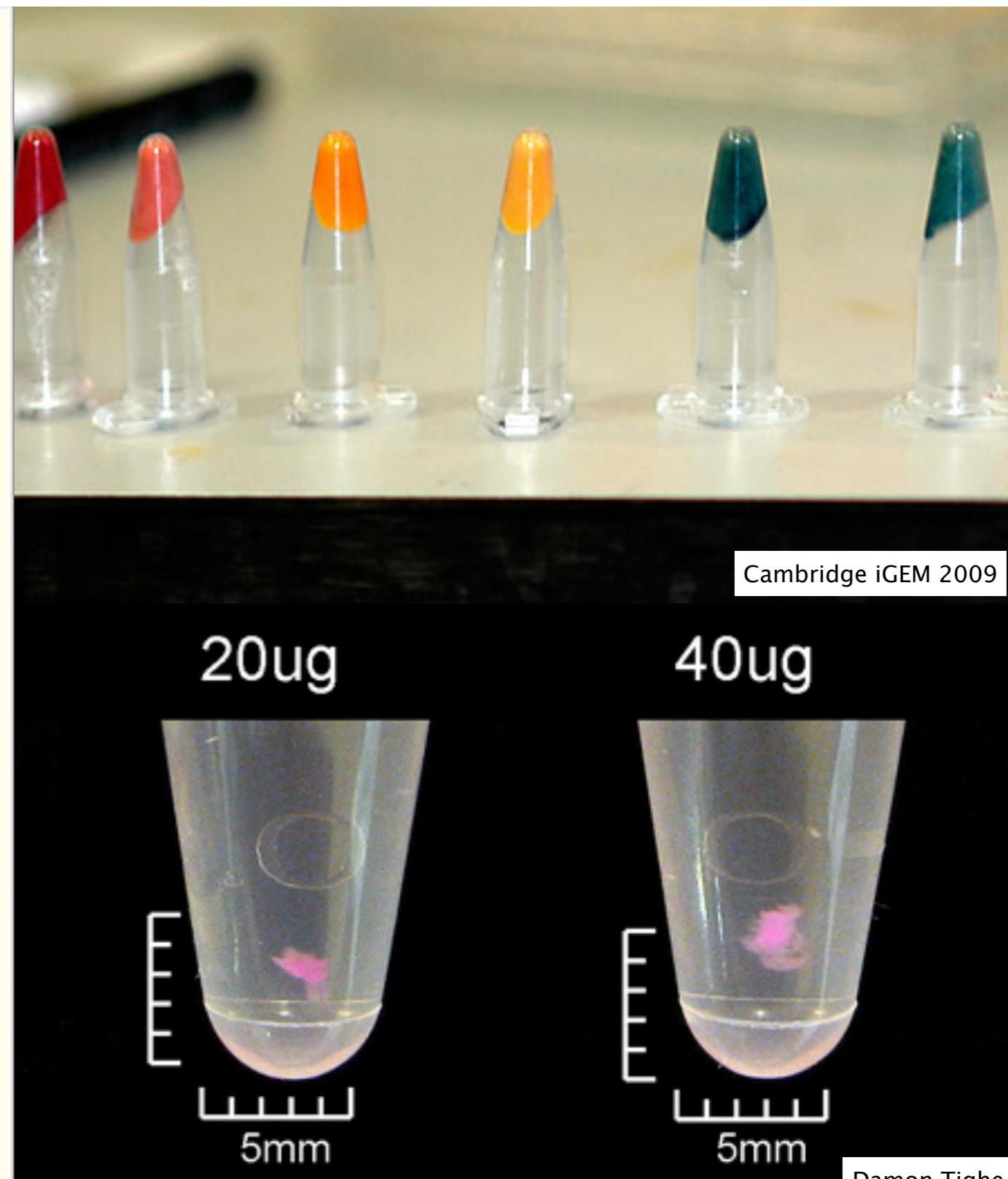
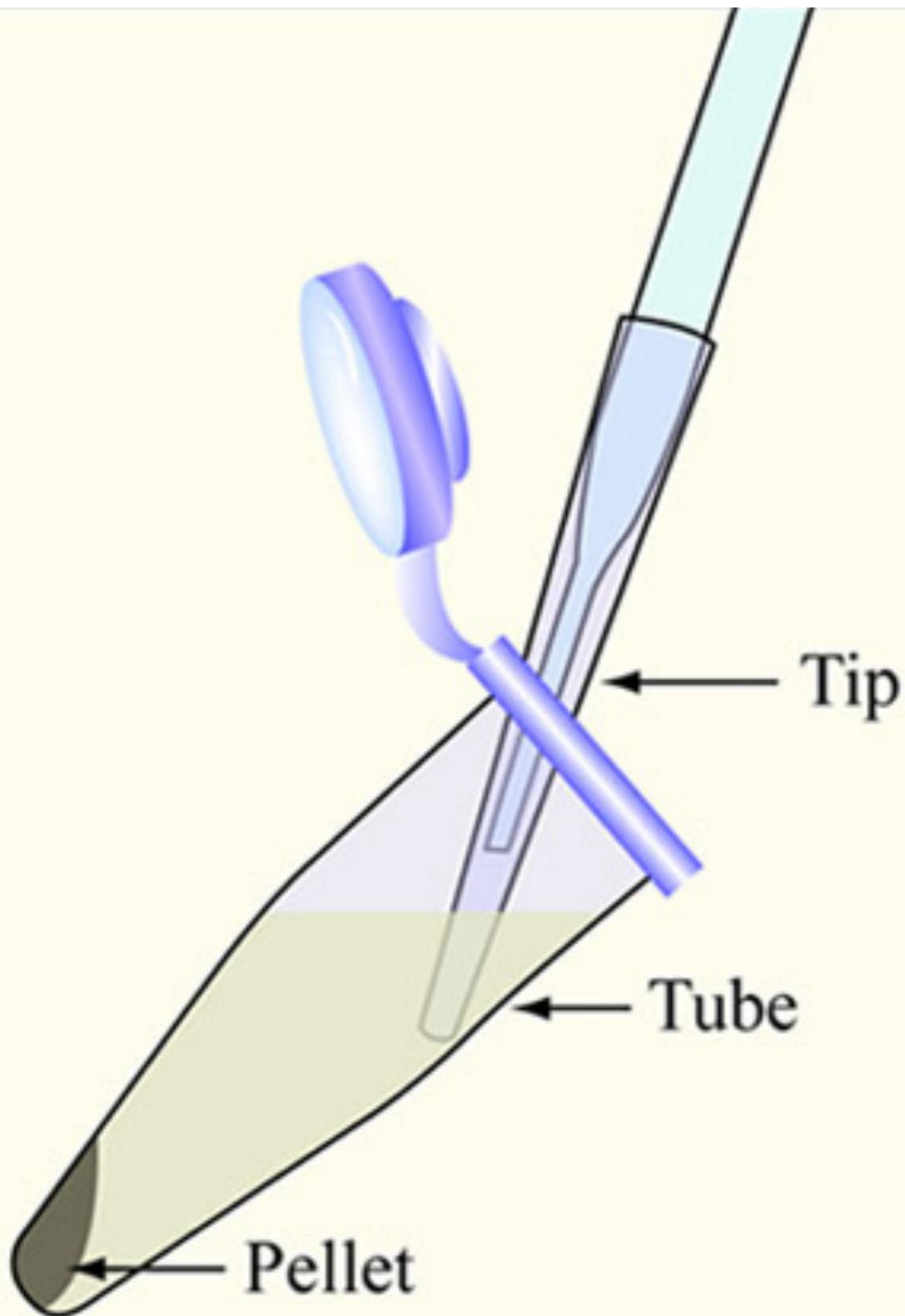
waag society

institute for art, science and technology

BioHack Academy Centrifuge Design



Centrifugation





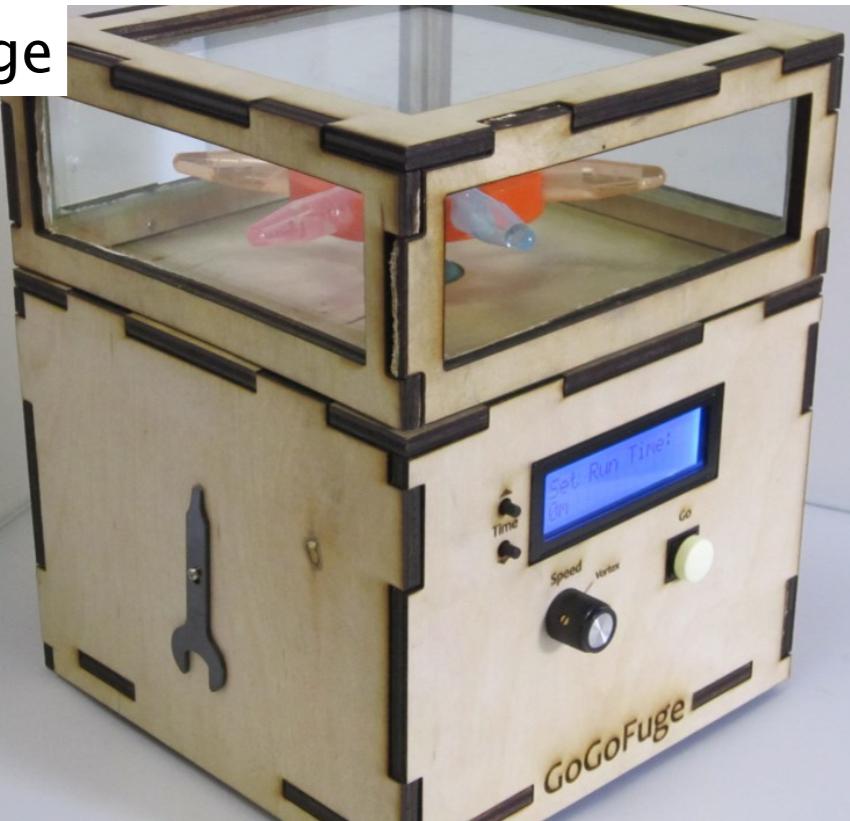
Industry standards



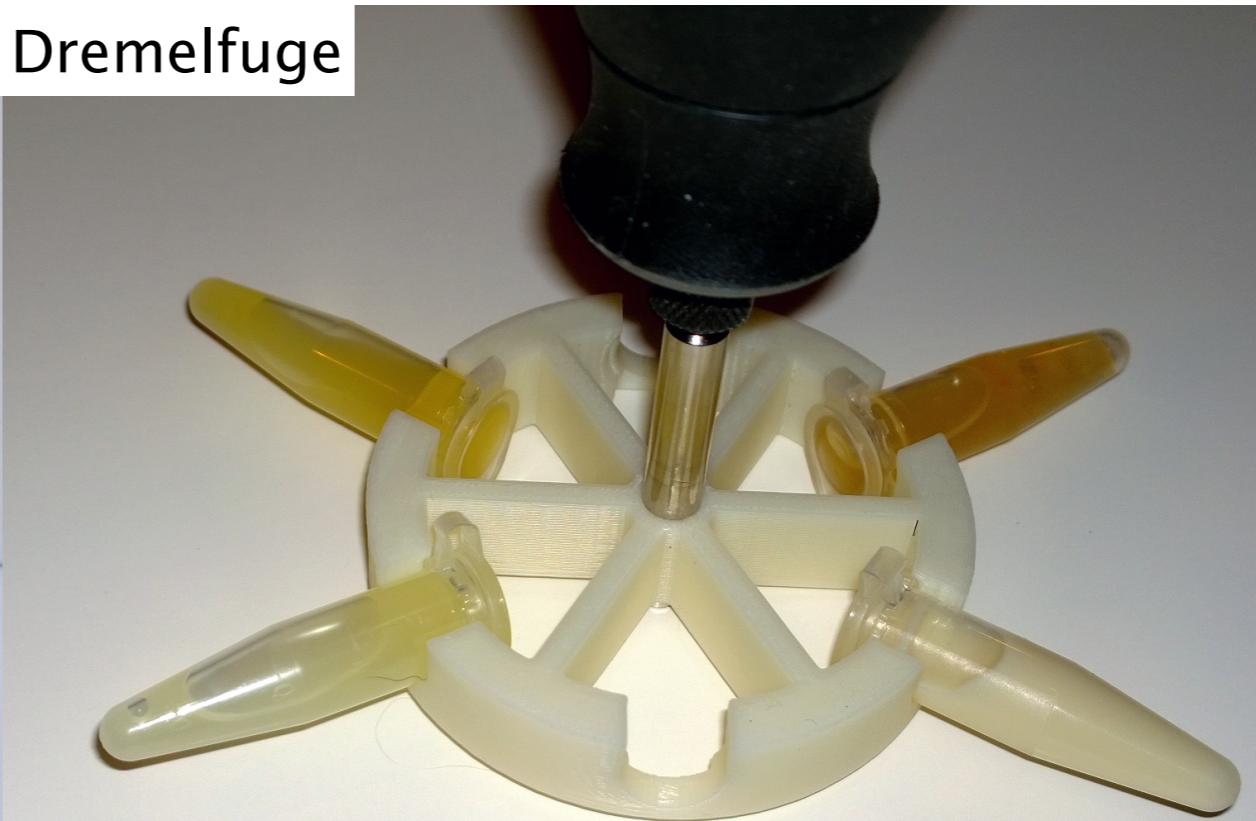


Centrifuge hacks

GoGoFuge



Dremelfuge



OpenFuge



Hackteria harddrive hack





Design constraints



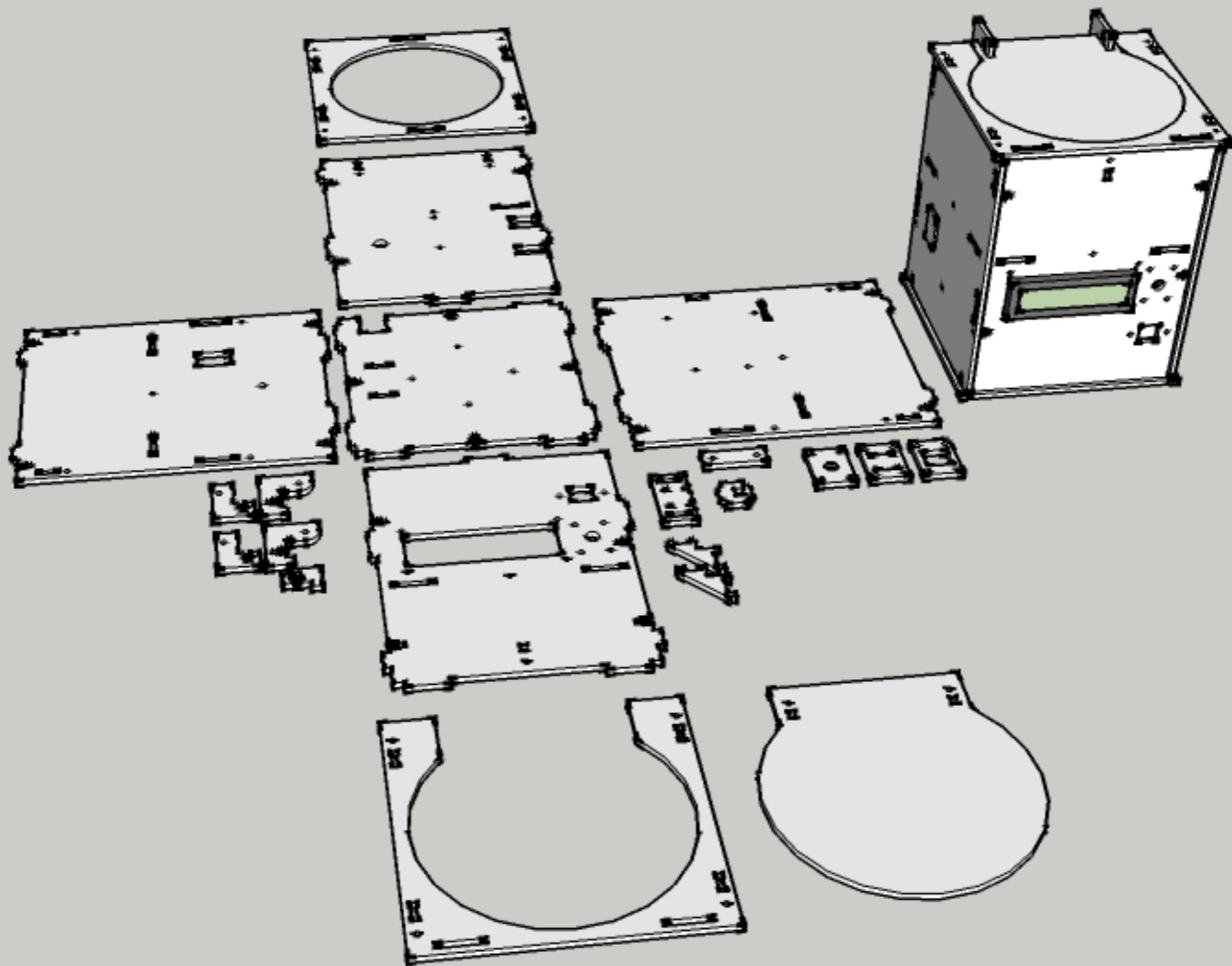


Notice

- NEVER test your centrifuge with a rotor attached

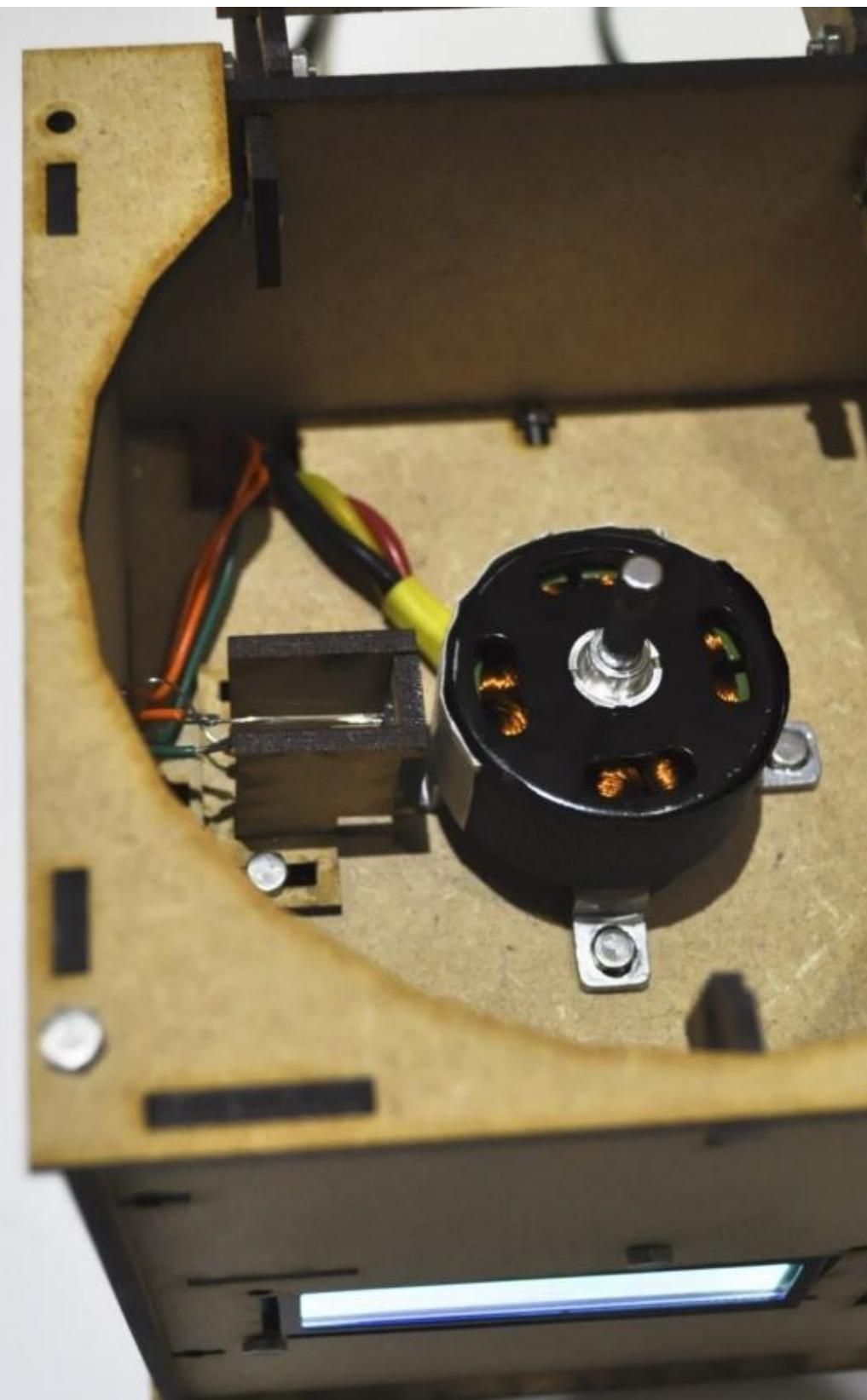
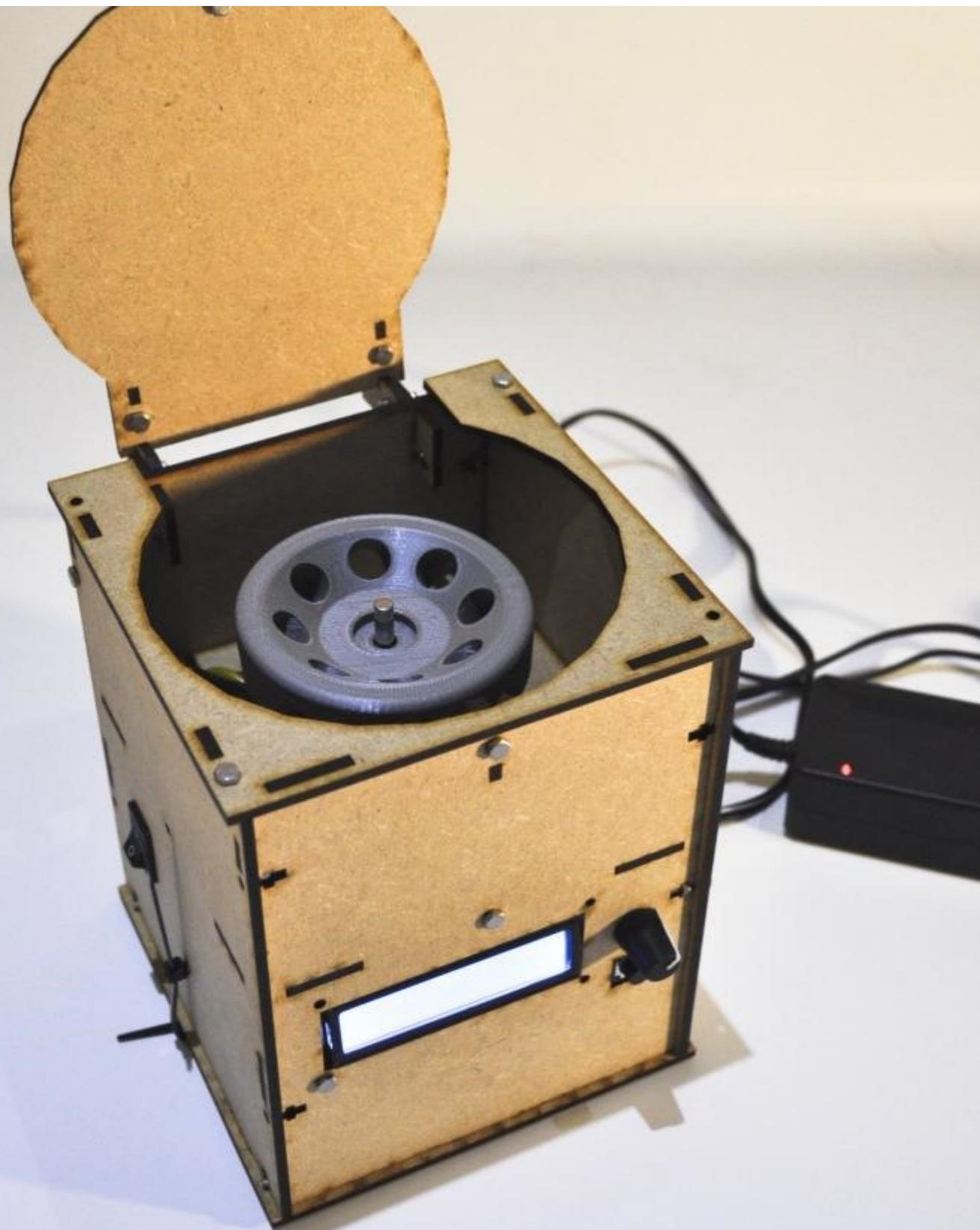


BioHack Academy design





Some pictures





Bill of Materials

No	Amount	Description	Supplier NL	Cost
1	1	DC Brushless motor 800 RPM/V & Electronic Speed Controller	HobbyKing	15.22
2	1	3.5mm connector	HobbyKing	3.14
3	1	Rotary encoder	Farnell, iPrototype, EOO	0.42
4	1	Knob	Farnell	0.23
5	1	Power switch	Farnell, iPrototype	0.71
6	1	DC power jack	Farnell, EOO	0.85
7	1	12V 5A Power supply	Farnell, EOO	38.13
8	1	Push button	Farnell, iPrototype, Sparkfun	0.47
9	1	10K resistor	Farnell, EOO	0.03
10	4	Rubber feet	Conrad	0.08
11	1	Infrared sensor	Farnell	1.70
12	1	6.8 KOhm resistor	Farnell	0.02
13	1	220 Ohm resistor	Farnell	0.02
16	1	I2C LCD display	iPrototype, Hackerstore	8.95
17	2	10K resistor	Farnell, EOO	0.6
18	2	10nF capacitor	Farnell, iPrototype, EOO	0.14
19	2	100nF capacitor	Farnell, EOO	0.14
20	1	Breadboard	Farnell, iPrototype	2.56



Motor

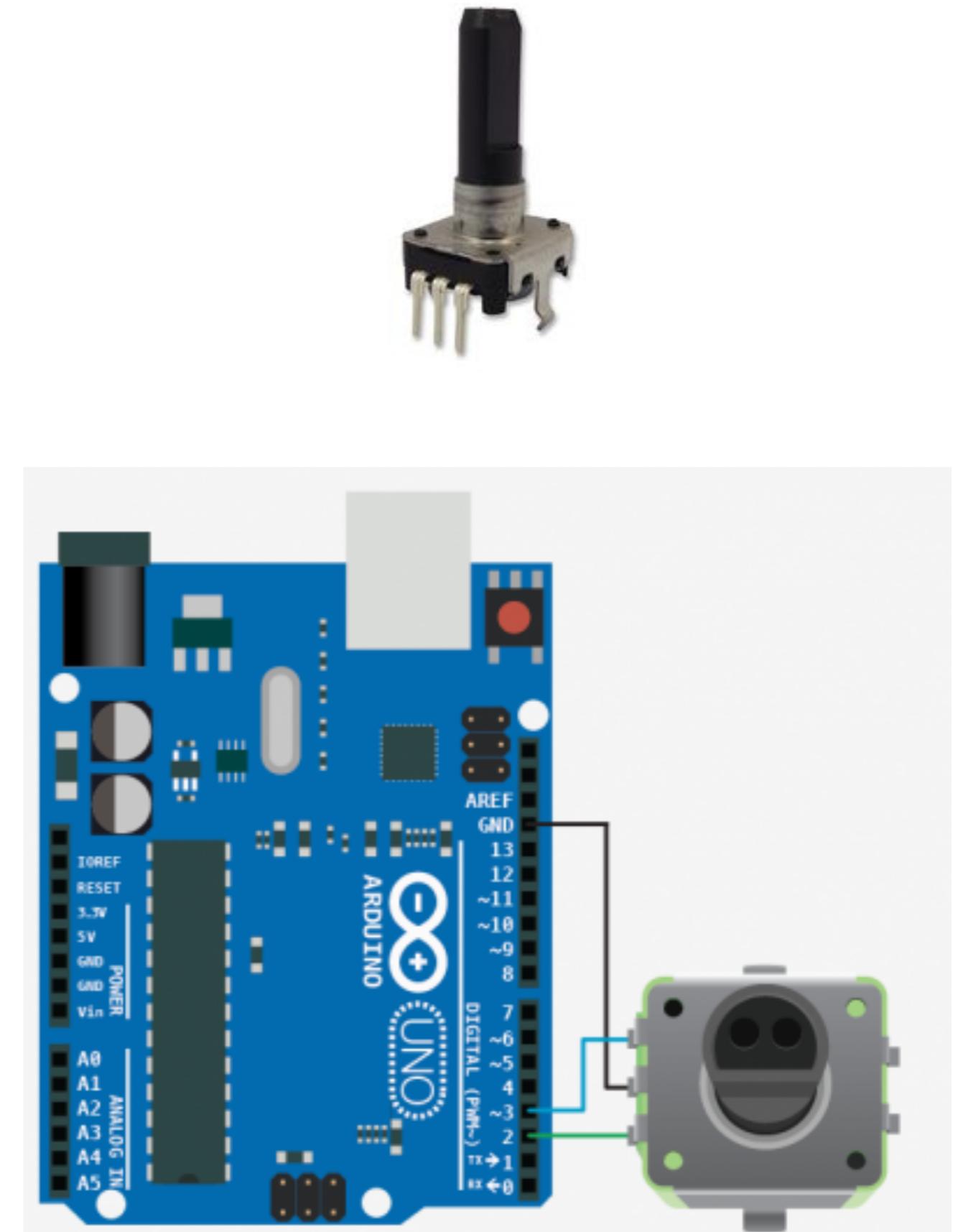
- Brushless
 - 810 KV
 - $\text{RPM} / V = 810$
 - 12V, so 9720 RPM
- ESC
 - power limit
 - voltage regulator





24 steps rotary encoder

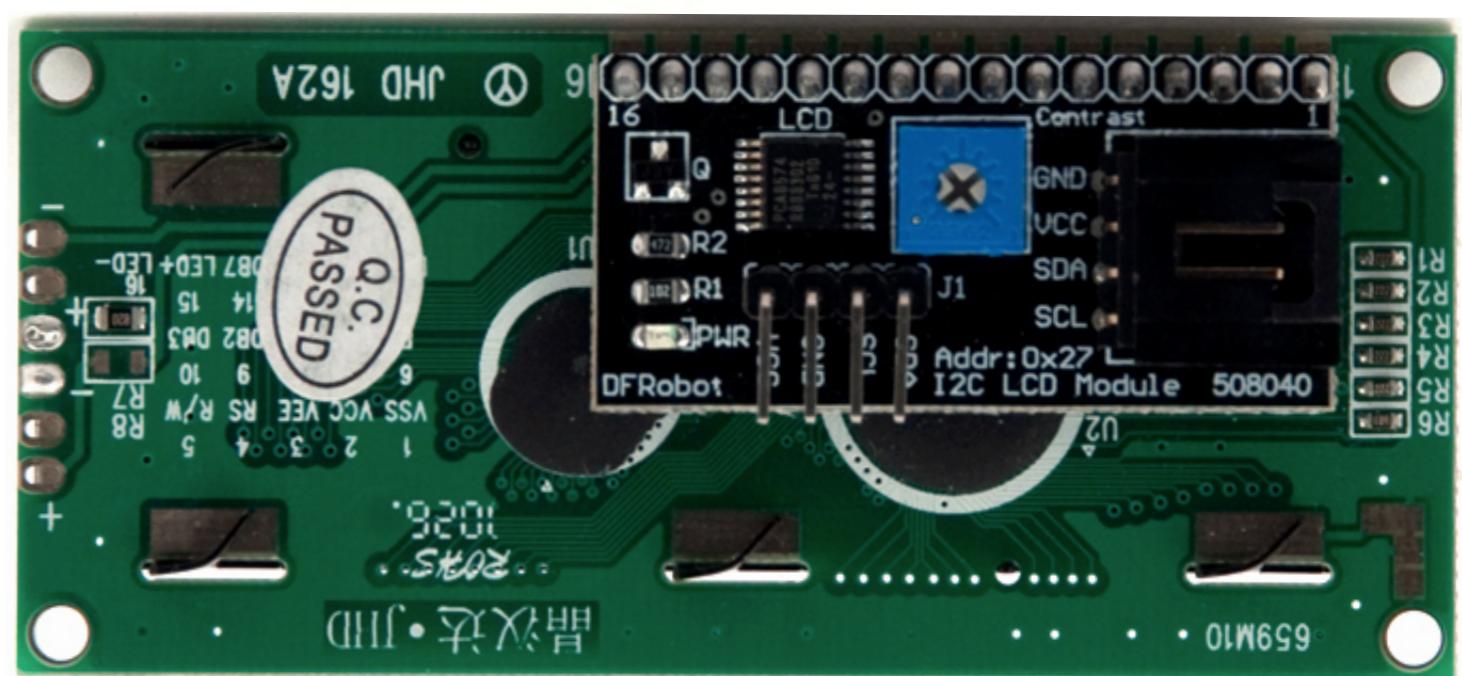
- Rotates infinitely
- 3 pins:
 - GND
 - State1
 - State2
- 2 bits:
 - 00
 - 01
 - 11
 - 10
- Interrupt pins
 - attachInterrupt()
- Demo code in Syllabus





I2C Display

- Arduino I2C ports
 - SCL -> A5
 - SDA -> A4
 - Libraries
 - Wire
 - LiquidCrystal_I2C
 - Demo code in Syllabus





Heavy weight

- Stabilising the machine





Infrared sensor

- Emitter
- Detector
- `pulseIn()` function
 - <http://arduino.cc/en/Reference/pulseIn>





Roller coaster

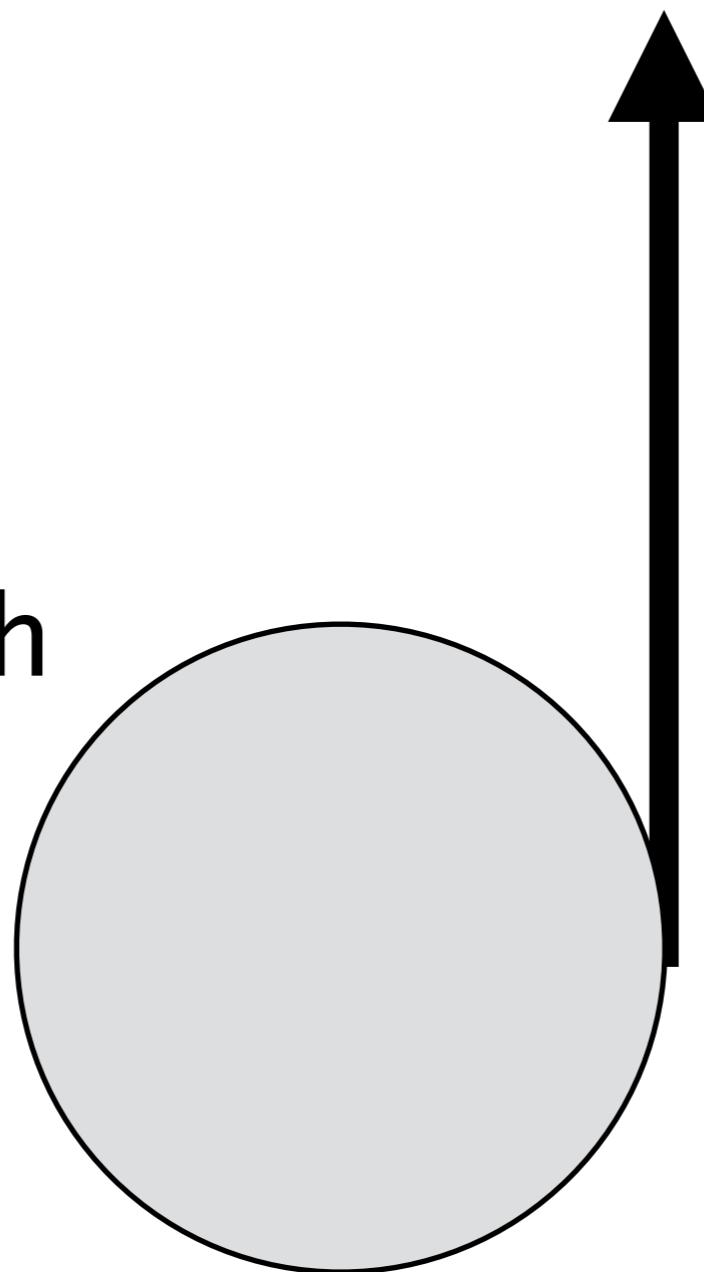




Centrifugal force

Circular path

Inertial path



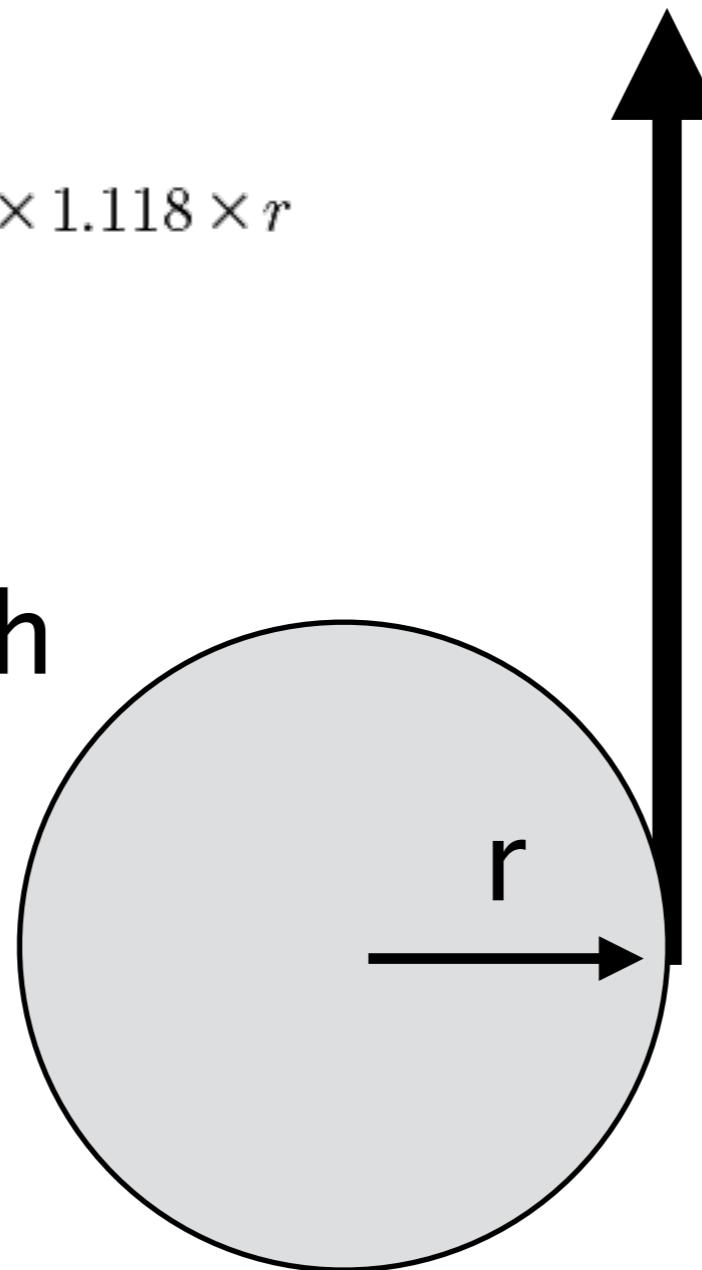


Centrifugal force

Inertial path

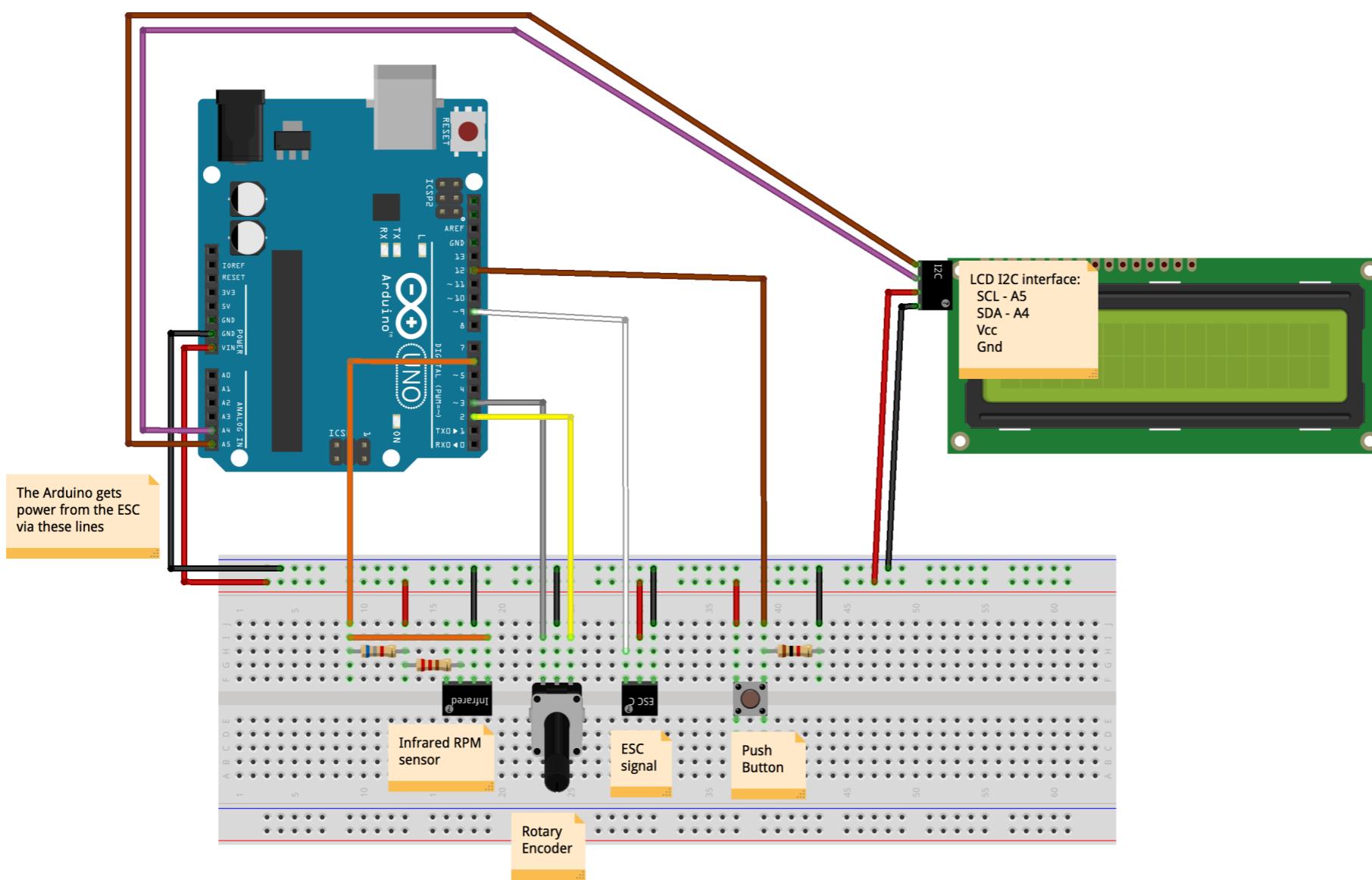
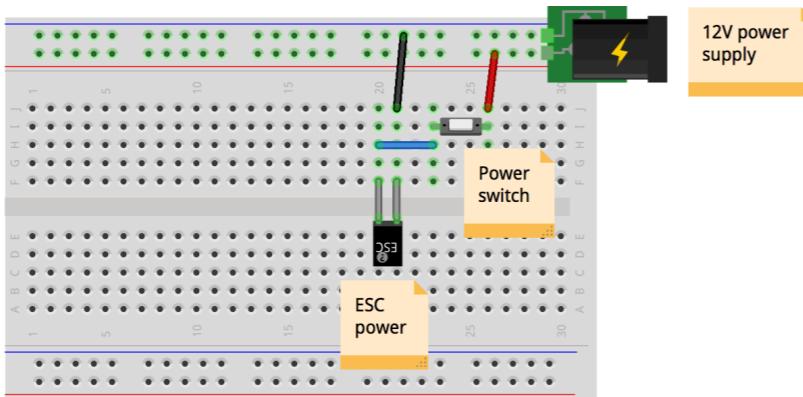
$$G \text{ force} = \left(\frac{RPM}{1,000} \right)^2 \times 1.118 \times r$$

Circular path



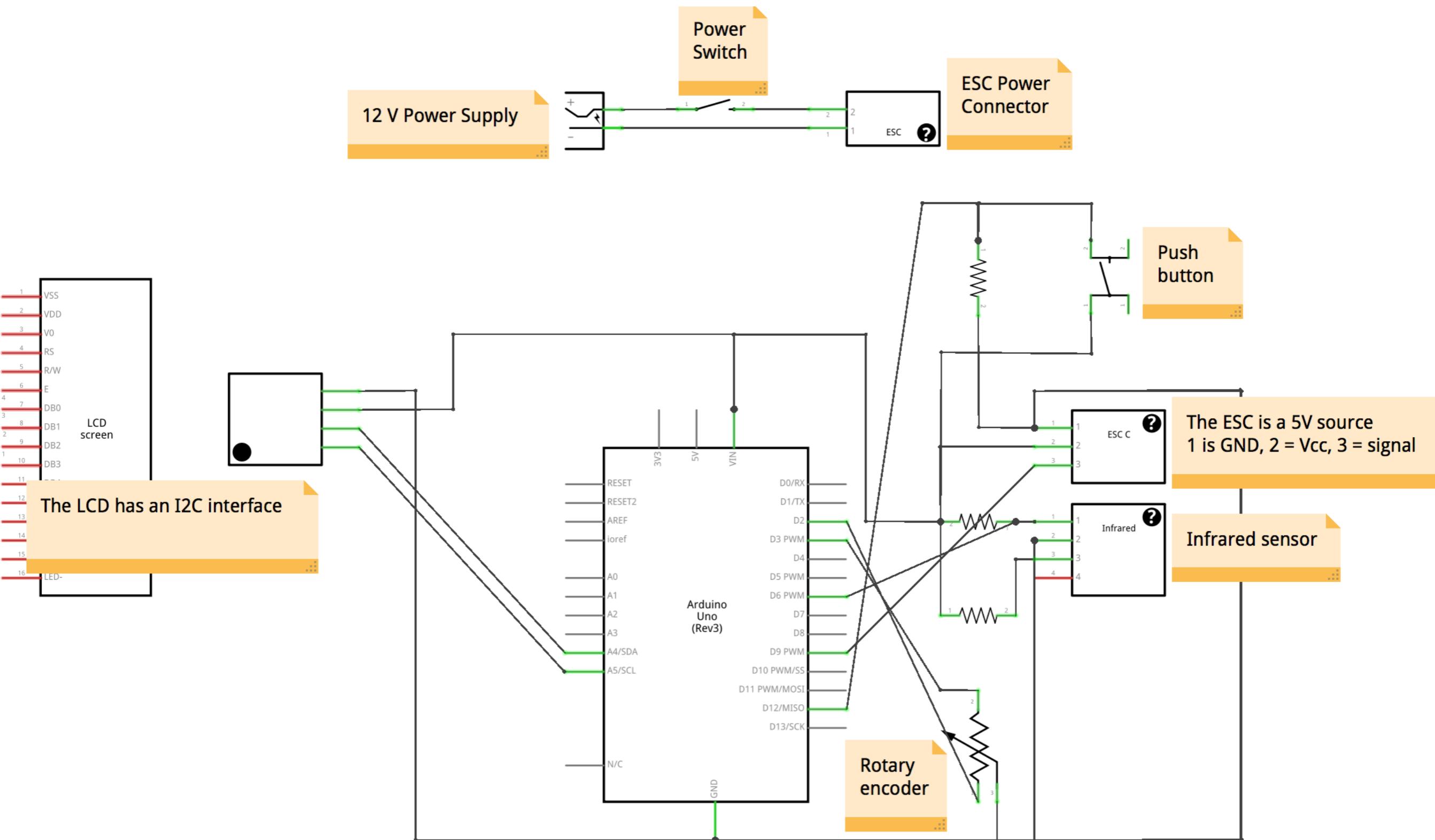


Wiring





Circuit scheme



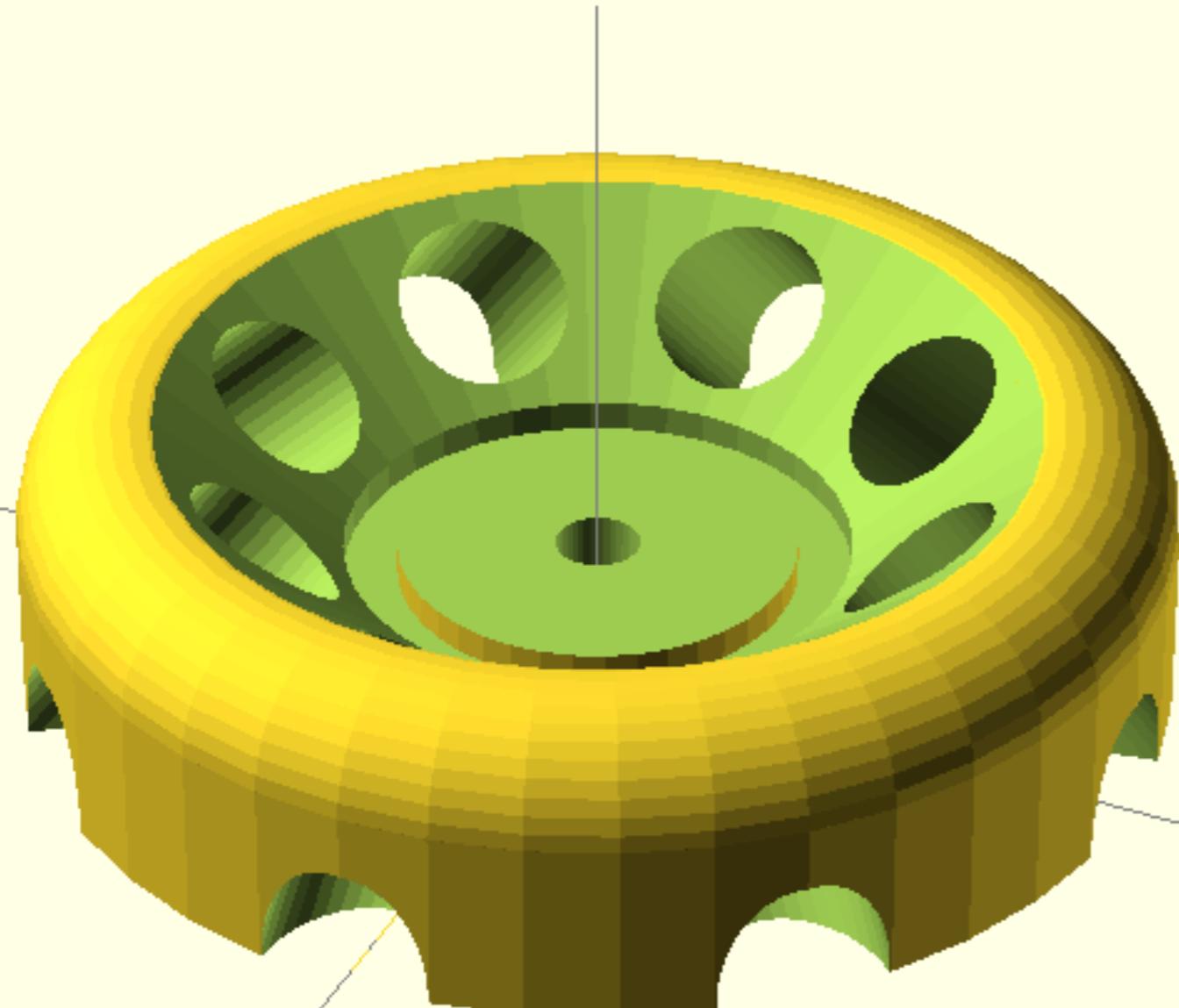


Code tutorials

- Rotary encoder
 - <http://bildr.org/2012/08/rotary-encoder-arduino/>
- I2C LCD
 - <http://playground.arduino.cc/Code/LCDi2c>
- Infrared sensor
 - <http://bildr.org/2011/03/various-proximity-sensors-arduino/>
- Arduino + Electronic Speed Controller
 - <http://www.instructables.com/id/ESC-Programming-on-Arduino-Hobbyking-ESC/>



Rotor



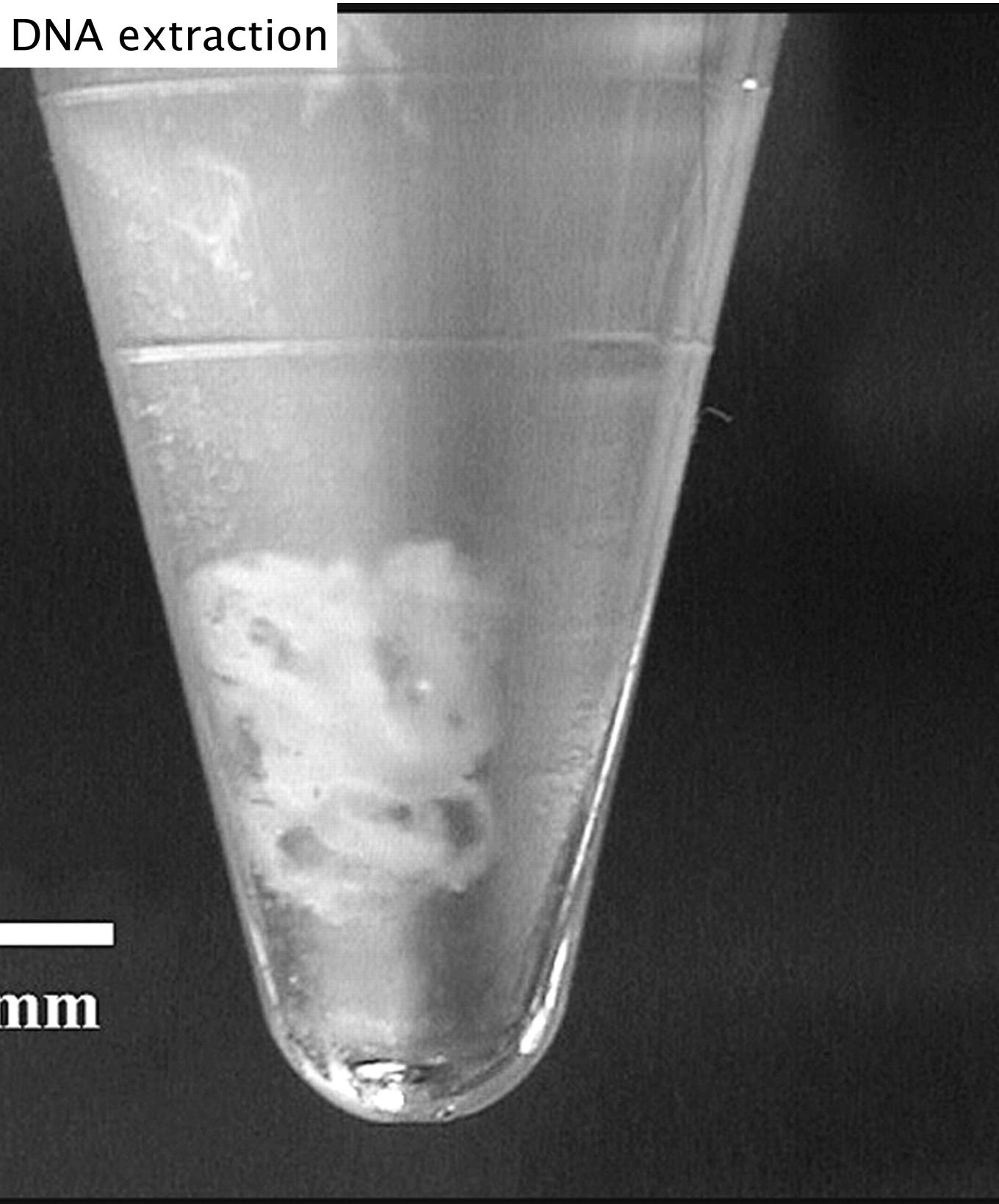
NEVER test your centrifuge with a rotor attached

```
$fn=40; // resolution of the arcs  
  
axis_radius = 0.275; // radius of the motor shaft  
  
tube_radius = 0.575; // inner radius of the tube holders  
tube_angle = 45; // angle in the rotor  
tube_pos = 4.75; // position of tube holders  
  
scale([10,10,10]) { // cm to mm scaling  
  
difference() { // subtract tube holders from outer ring  
  
difference() { // subtract inner groove  
  
difference() { // subtract cone from main disk  
  
union() {  
    cylinder (h = 1.25, r=3.75); // main disk part 1  
    cylinder (h = 1.9, r=3.25); // main disk part 2  
  
    // smoothen edge torus  
    translate([0,0,1.25])  
    rotate_extrude(convexity = 10)  
    translate([3, 0, 0])  
    circle(r = 0.75);  
}  
  
translate([0,0,1]) // raise cone from bottom  
cylinder (h = 1.1, r1 = 1.65, r2 = 3, center = false); // cone  
  
translate([0,0,-0.1])  
cylinder (h = 1.2, r = axis_radius); // axis  
  
// groove under tube holders  
translate([0,0,0.8])  
difference() { // ring
```

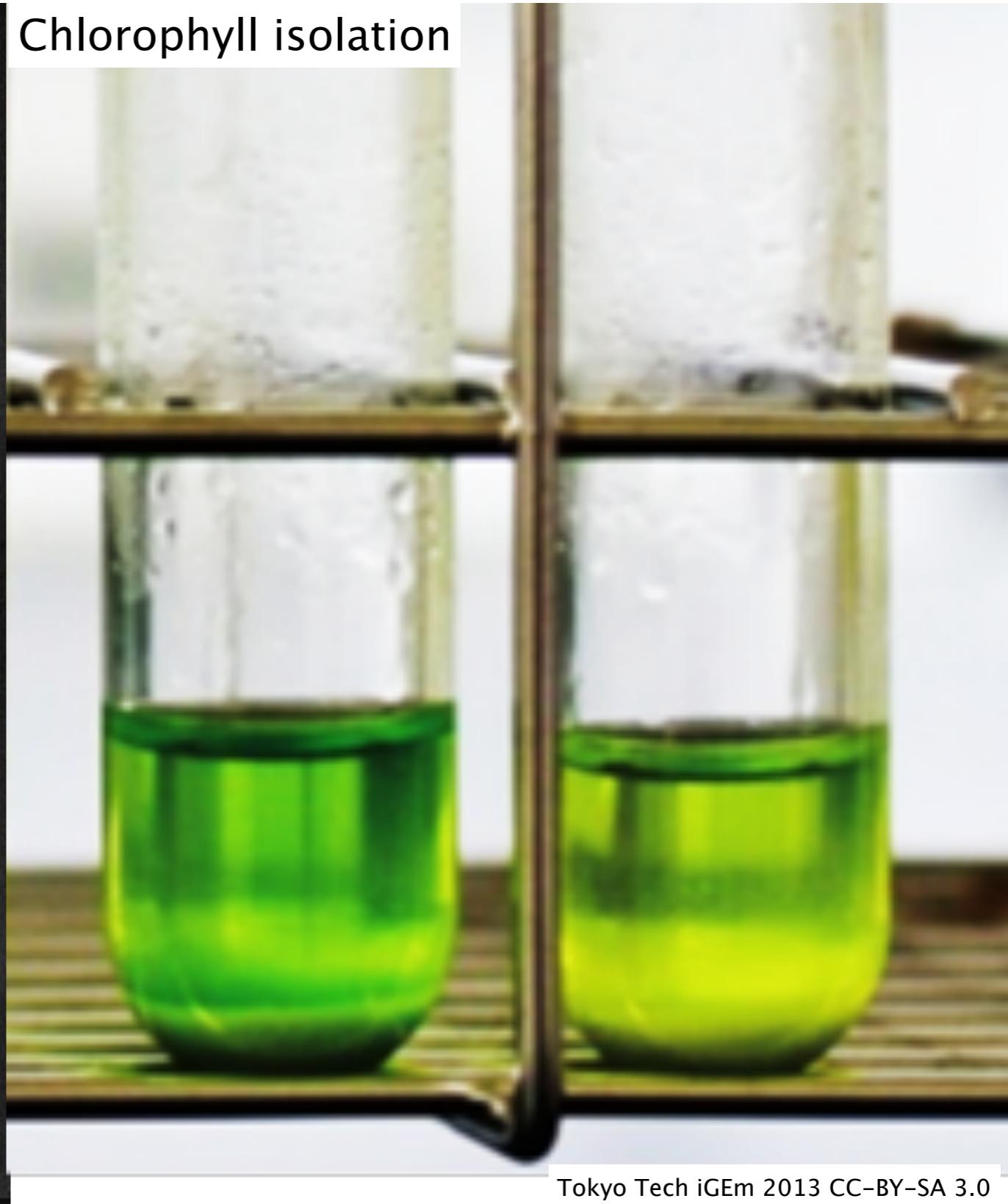


Practicals

DNA extraction



Chlorophyll isolation





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