Place all links to useful information here from now on. Either add to an existing category to place the link, or make a new category. Also add a description of what the link contains.

Bullets shortcut = ctrl+shift+8

Strikethrough shortcut = alt+shift+5

**3D model for Servos**

<https://www.thingiverse.com/thing:2467743>

SMD Surface Mount Devices sizing:

* 1206: Large
* 0805: medium
* 0603: small

Potentially use M2.5 screws with “standoffs” for raising the PCB off the bottom of the case.

Arrow Components to potentially order:

* DC Barrel Jack (already ordered off of Arrow, it’s an Adafruit product)
  + On Arrow: <https://www.arrow.com/en/products/3642/adafruit-industries>
  + On Adafruit: <https://www.adafruit.com/product/3642>
  + Schematic drawing: <https://cdn-shop.adafruit.com/product-files/3642/3642_diagram.pdf>
* Power Supply Electrolytic 10uF 5x5.4mm Capacitor UWT1V100MCL1GB
  + On Arrow: <https://www.arrow.com/en/products/uwt1v100mcl1gb/nichicon>
  + Datasheet (terribly confusing, but it’s the top capacitor drawing) <http://static6.arrow.com/aropdfconversion/f50e7127f699cba8b11ecc82ae216df337381fba/897e-uwt.pdf>
* Micro USB type B <https://www.arrow.com/en/products/47346-0001/molex>
  + Product on its Website <https://www.molex.com/molex/products/datasheet.jsp?part=active/0473460001_IO_CONNECTORS.xml>
  + Footprint <https://www.molex.com/pdm_docs/sd/473460001_sd.pdf>
* 1206 size SMD Components:
  + LED (yellow-green): QBLP650-AG <https://www.arrow.com/en/products/qblp650-ag/qt-brightek-corporation>
  + 1k resistor (for LEDs): <https://www.arrow.com/en/products/ac1206jr-071kl/yageo>
  + 10k resistor (for reset pull-up): <https://www.arrow.com/en/products/sg73g2bttd1002d/koa-speer-electronics>
  + 22 ohm resistor (for micro USB): <https://www.arrow.com/en/products/sg73g2bttd22r0d/koa-speer-electronics>
  + 4.7uF cap (16V limit, used with regulator): <https://www.arrow.com/en/products/cl31a475kohnnne/samsung-electro-mechanics>
  + 10uF cap (16V limit, used with regulator): <https://www.arrow.com/en/products/cl31a106koclnnc/samsung-electro-mechanics>
  + 1uF cap (50V, for UCAP pins): <https://www.arrow.com/en/products/c1206x105k5recauto/kemet-corporation>
  + 0.1uF cap (50V, for Vcc pins): <https://www.arrow.com/en/products/c1206c104k5jactu/kemet-corporation>
  + ~~0.33uF cap (50V):~~ <https://www.arrow.com/en/products/c1206c334k5rac/kemet-corporation>
    - Cap Naming scheme <http://static6.arrow.com/aropdfconversion/8b879375140a9ce8fc9ab71e64f51703685e747a/1919828050648244x7rdielectric.pdf>
* 5v 3A regulator (MIC29310-5.0WU) (one regulator for both of the servos): <https://www.arrow.com/en/products/mic29310-5.0wu/microchip-technology>
  + Datasheet <http://static6.arrow.com/aropdfconversion/ab7d7dcdfe3eb6b05f8d19ce53e1ca4c92cd3b20/mic29310.pdf>
  + Caps:
    - 10uF shunt output (output-to-gnd) cap
    - 0.1uF shunt input (input-to-gnd) cap
* 5V 0.5A Regulator (NCP5501DT50RKG) for the MCU
  + On Arrow: <https://www.arrow.com/en/products/ncp5501dt50rkg/on-semiconductor>
  + Datasheet: <http://static6.arrow.com/aropdfconversion/b2ea652e33e806fe892d4e0cc98108a95320f27/1535ncp5500-d.pdf>
  + Caps:
    - 10uF shunt input cap
    - 4.7uF shunt output cap
* Switch Reset push button: <https://www.arrow.com/en/products/fsm2jsmltr/te-connectivity>
  + Datasheet: <http://static6.arrow.com/aropdfconversion/1ae8d661c32b52a6d46a3c0683c6ffb1880b7a3f/eng_cat_1308390_0904_e3_e10_.pdf>
* Crystal Oscillators
  + Application notes from Microchip: <http://ww1.microchip.com/downloads/en/appnotes/00826a.pdfv>
  + 16MHz Quartz Crystal ($0.27) <https://www.arrow.com/en/products/ats160sm-1/cts>
    - Datasheet: <http://static6.arrow.com/aropdfconversion/7628a2618c9ec1dab32df4416d1edfd9e097661f/813008-0309-0.pdf>
  + 22pF 0805 Capacitor (two would be used with the crystal, C\_L = ½\*Cap + 5pF) <https://www.arrow.com/en/products/08052a220jat2a/avx>

Enclosure Options:

* <https://www.google.com/search?q=adafruit+aluminum+enclosure&rlz=1C1AVNE_enUS725US725&oq=adafruit+aluminum+enclosure&aqs=chrome..69i57.10214j0j4&sourceid=chrome&ie=UTF-8>
* <https://www.adafruit.com/product/2229?gclid=EAIaIQobChMIw9Cg04LB3gIVl6DsCh3tlAtBEAQYAiABEgI3HvD_BwE>
* Maybe too small: <https://www.adafruit.com/product/3253>
* Ethan’s box, so we should not use this one: <https://www.adafruit.com/product/3252>
* <https://www.amazon.com/dp/B0725RDKDL/ref=psdc_495308_t1_B07CPQ8R9M>

**Market Competition and existing DIY Projects**

* Sturdy 6-lb max load product: <https://www.bhphotovideo.com/c/product/64399-REG/Bescor_MP101_MP_101_Motorized_Pan_Head.html>
* Other DIY-ish (or self-assembly) Products:
  + $53.95 simple two-servo bare-bones device <https://www.robotshop.com/en/lynxmotion-micro-pan-and-tilt-kit-with-servos-black.html?gclid=EAIaIQobChMIv5r86tWl3gIVSb7ACh0ZzQ_zEAQYBCABEgKU_vD_BwE>
  + $99.95 Sturdy two-servo metal structure <https://www.trossenrobotics.com/phantomx-pan-tilt?feed=Froogle&gclid=EAIaIQobChMIv5r86tWl3gIVSb7ACh0ZzQ_zEAQYBSABEgJUpPD_BwE>
  + $56.29 simple rotate and tilt camera mount product with arrow key remote <https://www.tomtop.com/p-d3207.html?currency=USD&Warehouse=US&aid=gplausyly&mid=10000018477&utm_source=SEM&utm_medium=Google+Adwords&utm_campaign=TT_PLA_YLY&utm_content=2945&gclid=EAIaIQobChMIv5r86tWl3gIVSb7ACh0ZzQ_zEAQYBiABEgKPzfD_BwE>
  + $39.00 Pan & Tilt Servo Motor kit with Camera on PCB board <https://www.amazon.com/Tilt-Servo-Motor-Pixy-CMUcam5/dp/B00IVOEN1Y>
* Video of DIY project assembly: <https://www.youtube.com/watch?v=4A7tJ0QH4L4&feature=youtu.be>

**General Servo Information**

* Arduino servo library
  + <https://github.com/arduino-libraries/Servo>
  + <https://www.arduino.cc/en/Reference/Servo>
  + <https://github.com/adafruit/Adafruit-PWM-Servo-Driver-Library>
  + <http://andrea-toscano.com/400hz-pwm-on-atmega32u4-for-multirotors-without-using-servo-library/>
* Adafruit on powering servos <https://learn.adafruit.com/adafruit-16-channel-pwm-servo-hat-for-raspberry-pi/powering-servos>
* About hobby servos (PWM, how they work, what’s inside, etc.) <https://learn.sparkfun.com/tutorials/hobby-servo-tutorial>
* Feedback Servos
  + <https://learn.adafruit.com/analog-feedback-servos/about-servos-and-feedback>
  + <https://learn.adafruit.com/analog-feedback-servos/using-feedback>
* Calculating torque requirements:
  + <https://www.motioncontroltips.com/8-easy-steps-to-selecting-the-right-servo-systems/>
* OUR SERVOS (SG90 9G Nylon-Gear Servos): <https://www.amazon.com/dp/B072V529YD/ref=cm_sw_r_cp_apa_e44ZBbRB9DYES>
  + 4.8V ratings:
    - Operating Speed: 0.09 seconds / 60°
    - Running Current: 400±30mA
    - Stall “Torque”: 2.0±0.2 kg.cm (27.77oz.in±2.777oz.in)
    - Stall current: 1300±40mA
    - Idle current: 6±1mA
    - Running life: 350,000 turns
    - Temperature drift less than 5°C
  + Example of functional device using same servos: <http://jume-maker.blogspot.com/2018/07/how-to-control-servo-pan-tilt-kit-using.html?m=1>
  + Another example: <https://www.youtube.com/watch?v=16iis1YEekc&feature=youtu.be>
* Heavy duty servo with bracket <https://www.amazon.com/dp/B072KCZXNW/ref=sspa_dk_detail_1?psc=1&pd_rd_i=B072KCZXNW&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=f52e26da-1287-4616-824b-efc564ff75a4&pf_rd_r=Q3TJA1XPC4B10EDXQCK1&pd_rd_wg=cnf2C&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&pd_rd_w=vx2vT&pf_rd_i=desktop-dp-sims&pd_rd_r=d0f9aa8e-db11-11e8-a761-fbfc222943f1>
* Metal Gear MG90S Servos on Amazon (Roughly same size as SG90 Nylon-gear servos)
  + 6-pack $20.99 Best deal and best reviews (all positive reviews) <https://www.amazon.com/dp/B07F7VJQL5/ref=sspa_dk_detail_4?psc=1&pd_rd_i=B07F7VJQL5&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=21517efd-b385-405b-a405-9a37af61b5b4&pf_rd_r=H3NZD20EX7CXSQTTR87D&pd_rd_wg=dIIi7&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&pd_rd_w=2vLrh&pf_rd_i=desktop-dp-sims&pd_rd_r=8d033dda-de2b-11e8-99eb-878844a4b2d8>
  + 5-pack $16.99 <https://www.amazon.com/dp/B07FLXZ1VK/ref=sspa_dk_detail_2?psc=1&pd_rd_i=B07FLXZ1VK&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=21517efd-b385-405b-a405-9a37af61b5b4&pd_rd_wg=FsYgP&pf_rd_r=EMABY0317Y9MPP9H79N4&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&pd_rd_w=8TnUp&pf_rd_i=desktop-dp-sims&pd_rd_r=7848884c-df7f-11e8-b0d8-93b4608d6f9a>
  + 5-pack $19.99 <https://www.amazon.com/dp/B071J7BGV8/ref=sspa_dk_detail_7?psc=1&pd_rd_i=B071J7BGV8>
  + 4-pack $16.99 <https://www.amazon.com/dp/B00M8SR0ZK/ref=psdc_2234131011_t2_B07F7VJQL5>

**Servo Brackets**

* <https://www.robotshop.com/en/servo-brakets.html>

**PWM Control for Servos with ATmega32U4**

* Has example of using timers with clock to set duty cycle: <http://extremeelectronics.co.in/avr-tutorials/servo-motor-control-by-using-avr-atmega32-microcontroller>

**ATmega32U4 Datasheet, Info, and Application Notes**

* Datasheet: <http://ww1.microchip.com/downloads/en/devicedoc/atmel-7766-8-bit-avr-atmega16u4-32u4_datasheet.pdf>
  + Clock Sources Section 6.2 (See link about fuse settings: Table 28-5 on page 355)
  + Crystal Oscillators section 6.3
  + Table 28-5 on setting fuse bits
* Price on arrow:

<https://www.arrow.com/en/products/atmega32u4rc-au/microchip-technology>

* Microchip summary (Includes APPLICATION NOTES under documents): <https://www.microchip.com/wwwproducts/en/ATMEGA32U4>
* Adafruit BREAKOUT BOARD: <https://learn.adafruit.com/atmega32u4-breakout?view=all#download>
* Arduino comes preprogrammed with bootloader that allows USB programming

<https://arduino.stackexchange.com/questions/5165/atmega32u4-bootloader>

* Installing bootloader tips

<https://learn.sparkfun.com/tutorials/installing-an-arduino-bootloader/all>

<https://www.htlinux.com/bootloading-an-atmega32u4-with-arduino/>

* Adafruit Atmega32u4 breakout board info

<https://cdn-learn.adafruit.com/downloads/pdf/atmega32u4-breakout.pdf>

**Micro USB Port Type B**

* On Arrow:<https://www.arrow.com/en/products/47346-0001/molex>
* Spec:<https://www.molex.com/molex/products/datasheet.jsp?part=active/0473460001_IO_CONNECTORS.xml>
  + Drawing:<https://www.molex.com/pdm_docs/sd/473460001_sd.pdf>

**Oscillator information**

* Internal vs. external oscillator: <https://www.allaboutcircuits.com/technical-articles/choosing-the-right-oscillator-for-your-microcontroller/>
* Choosing cap sizes: <https://blog.adafruit.com/2012/01/24/choosing-the-right-crystal-and-caps-for-your-design/?fbclid=IwAR1VHrsMbFiby3lVke6pwLF8nJr4EMVCZN0Lwc022UEI5X64AUz8dmkhQrE>

**Installing Arduino Bootloader**

* Installing bootloader: <https://learn.sparkfun.com/tutorials/installing-an-arduino-bootloader/all>
* Fuse Calculator!!! <http://www.engbedded.com/fusecalc/>

**Voltage Regulators**

* 3.3v regulator: <https://www.arrow.com/en/products/mic5225-3.3ym5-tr/microchip-technology>
* 5V 1A L7805ABV voltage regulator from the EPL (Note that it’s box in the EPL is mislabeled as a similar voltage regulator, but has the correct ratings: 5V 1A)
  + L7805ABV TO-220 package Datasheet <https://www.mouser.com/datasheet/2/389/l78-974043.pdf>

**Eagle CAD SCHEMATICS**

* <https://learn.sparkfun.com/tutorials/using-eagle-schematic/all>

**Eagle CAD PCB**

* Slotted holes?? <https://www.autodesk.com/products/eagle/blog/what-you-didnt-know-about-eagle-slotted-holes/?fbclid=IwAR0qJyyJBAHOUX0jj3py2eQ9Ia8K5YyF8kMd9ZGZnJEJ6nn76faaXHUe4Pw>
* Test Point Limitations: <https://www.element14.com/community/thread/8180/l/testpoints-for-ict-testers?displayFullThread=true>

**Remotes**

* <https://www.adafruit.com/product/1829>
* <https://www.adafruit.com/product/1332>
* <https://www.adafruit.com/product/419>
* <https://www.adafruit.com/product/3845>
* <https://www.adafruit.com/product/1660>
* <https://www.baldengineer.com/arduino-internal-pull-up-resistor-tutorial.html>

Challenges to address:

* Servos
  + Sufficient power (mA and Volts)
  + Smoothness of rotation
    - Resolution (accuracy to fraction of degree) limited by dead band no-positional-change?
  + Assembly with 3D printed framework
    - Metal axles with ball bearings?
* Microcontroller
  + Multiple inputs
    - Arrow key with four directions - Can the microcontroller respond to two buttons pressed at once, so that rotation and tilt can occur simultaneously?
    - Rejecting conflicting inputs, such as pressing left and right arrows simultaneously.
  + Output PWM signals
    - Limited rotation
      * Microcontroller must limit degree of rotation, and stop rotation when the max position is reached
    - Developing code that will increase/decrease the pulse width output at a constant rate while arrow is pressed and held for constant velocity of rotation
    - Updating output simultaneously (assuming response to two simultaneous inputs is possible)
  + Bootloader pre-installed on the chip, so this won’t be an issue.
* PCB
  + DC Power Supply
    - Batteries vs. wall AC-to-DC plug-in:
      * Batteries will require their own enclosure
      * Wall AC-to-DC plug-in will require the cord and converter, as well as a port for the plug-in on the PCB
      * <https://www.arrow.com/en/products/3642/adafruit-industries>
  + Prototyping operation with microcontroller breakout board and bread board