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

**3D model for Servos**

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

**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: <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>

**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>
* 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>

**Oscillator information**

* Internal vs. external oscillator: <https://www.allaboutcircuits.com/technical-articles/choosing-the-right-oscillator-for-your-microcontroller/>

**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>

**Eagle CAD SCHEMATICS**

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

**Eagle CAD PCB**

**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>

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