Microcontrollers in the Aviation Curriculum

Dr. Padraig Houlahan
Embry-Riddle Aeronautical University, Prescott, AZ.
SimaviaUSA, Prescott, AZ.

What needs are we trying to address?

- Educating Aviation students interested in careers as pilots
  - Students planning to enter an increasingly technical work environment:
    - More widespread use of glass-cockpits
    - More fly-by-wire systems
  - A demographic that is very experiential-learning oriented
  - Updating curricula to improve classroom teaching

Making technology more transparent

Assumptions:

- We believe pilot performance and operational effectiveness improves with understanding,
  - Increased comprehension of underlying technologies makes them less intimidating and increases comfort level
  - This results in greater satisfaction, confidence, and effectiveness

What are Micro-controllers?

- Essentially they are small dedicated computers
- Used for very specific purposes
- Don't necessarily need much CPU or RAM or Power because they are applied to very narrowly scoped applications

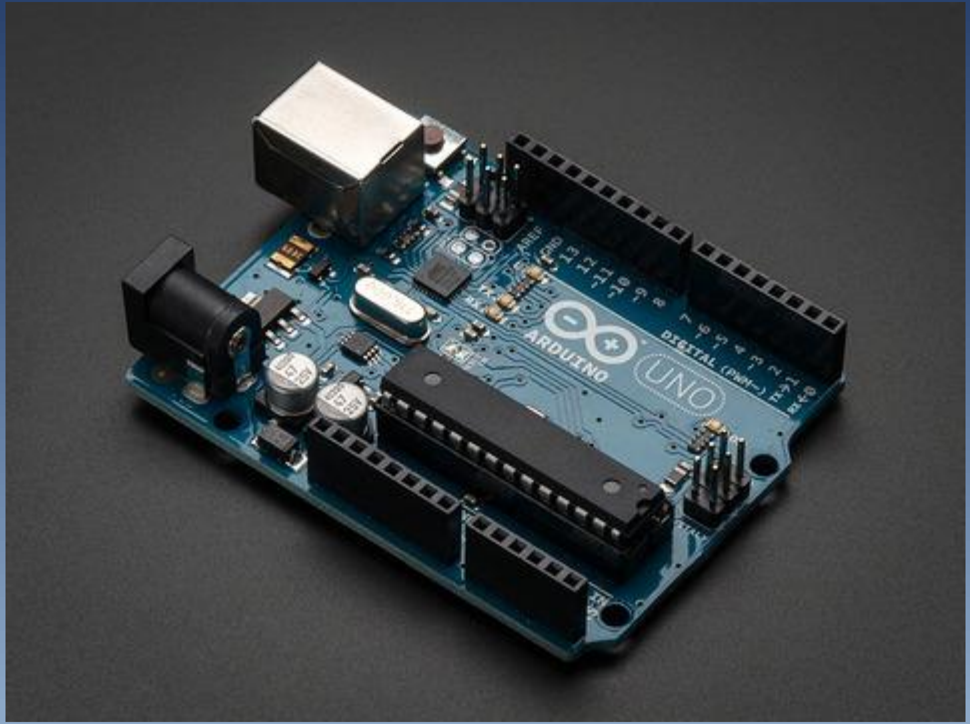
Now widely used and integrated into technology and science curricula at both high-school and undergraduate levels

Why use them in the curriculum?

- Explosion in their use to bridge the gap between software and hardware – makes them relevant beyond the classroom
- Large hobbyist and college user-base - online collections of freely available solutions.
- Relatively inexpensive options oriented to these markets – Arduino, Raspberry Pi
- They allow a level of access to technology previously only available to specialists such as engineering students and professionals.

Aviation students can use microcontrollers to learn about career related technologies
without having to become engineers!

Arduino, Raspberry Pi, etc.



Why are microcontrollers so powerful?

They allow us to:

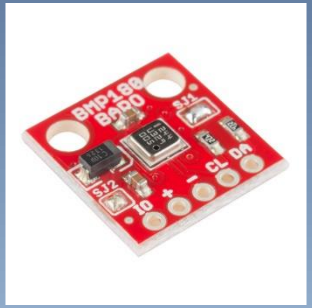
- Collect data from sensors
- Analyze the data
- Control output devices accordingly

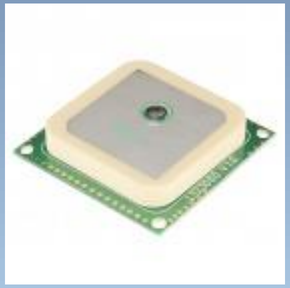
It’s all about Empowerment!

Microcontrollers can measure environmental and physical changes and intelligently (programmatically) produce appropriate physical responses

Sensors

- Passive
  - Temperature
  - Pressure
- Complex/Computer Chip
  - GPS
  - Acceleration
  - Rotation
- Mechanical
  - Respond to physical forces and motion





Using sensors

- Basic sensors often use 3 wires
  - Two for power (Vmax and ground)
  - One for signal

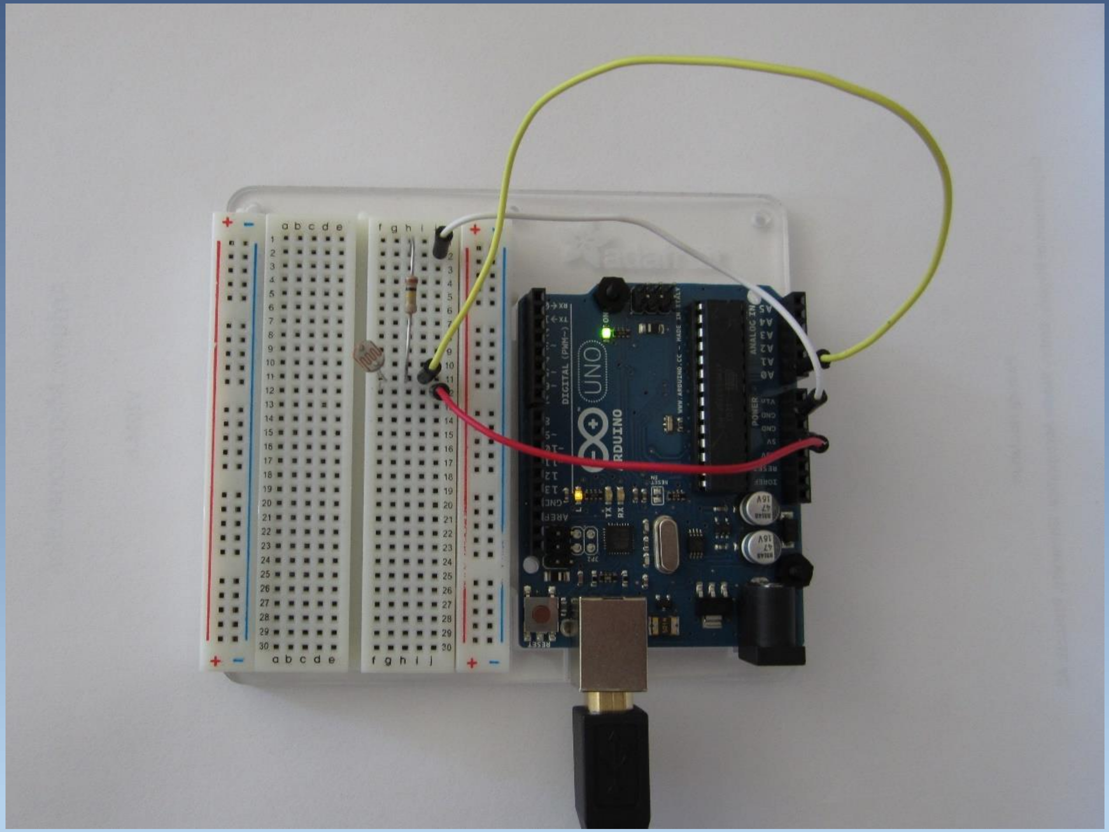
They essentially act as a device that produces a signal between 0v and Vmax volts.

Examples: potentiometers, light-sensitive resistors

Microcontrollers like the Arduino have built-in Analog-to-digital-converters (ADCs) that convert voltage levels to integers that can be read by software.

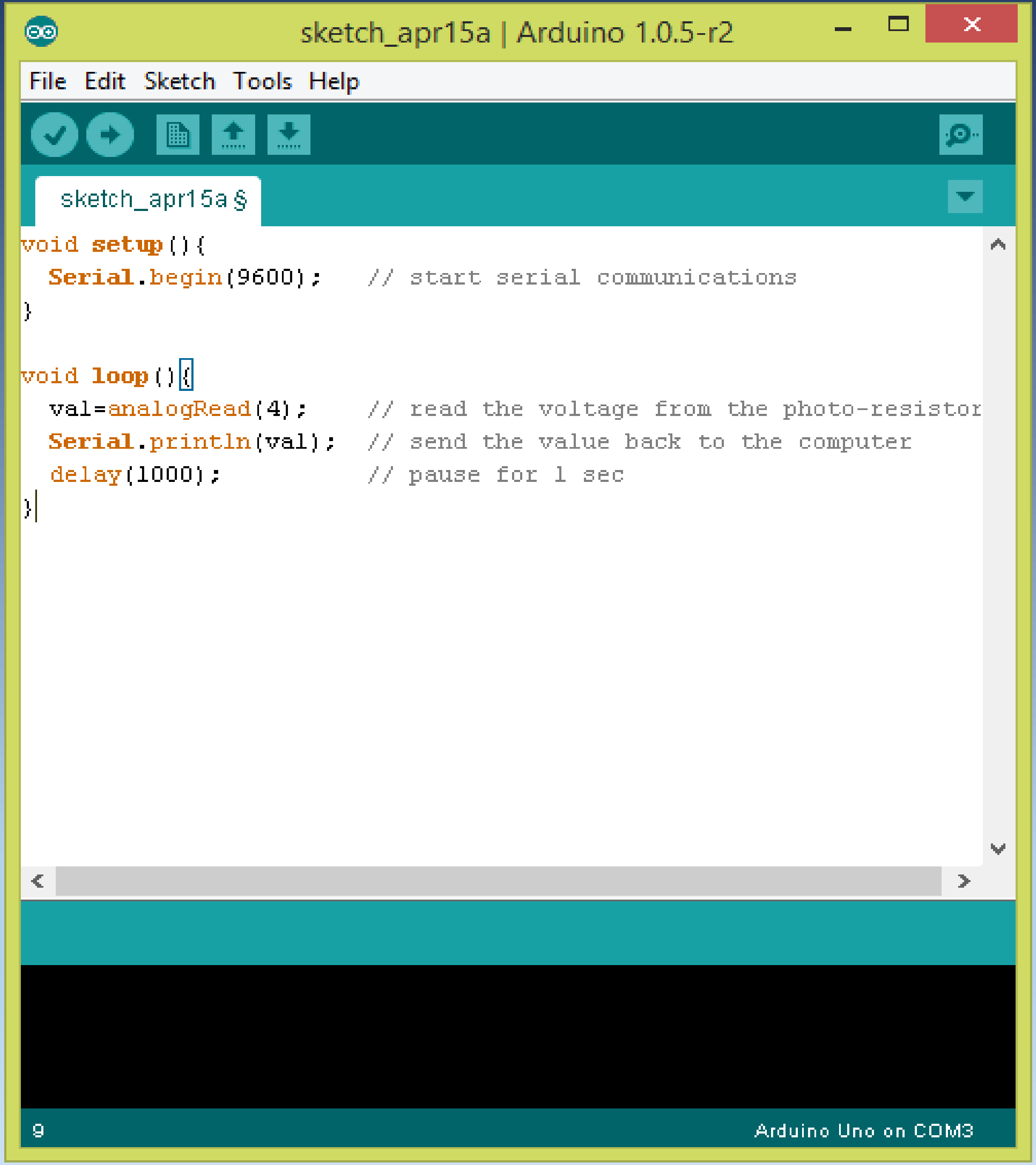
This allows for sensor inputs to be measured, or analyzed.

Measuring ambient light levels



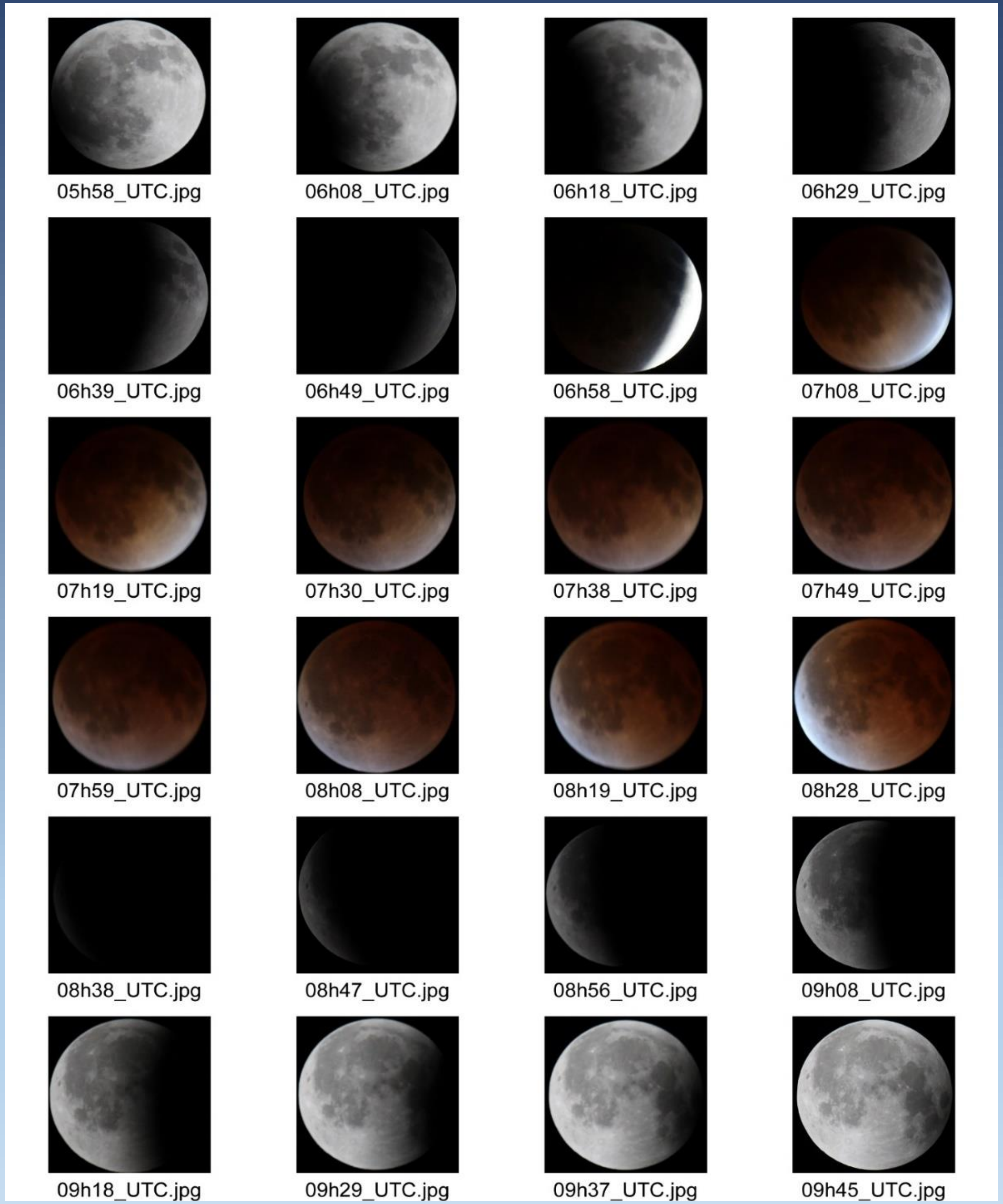
An extremely simple introductory circuit, well suited for young students

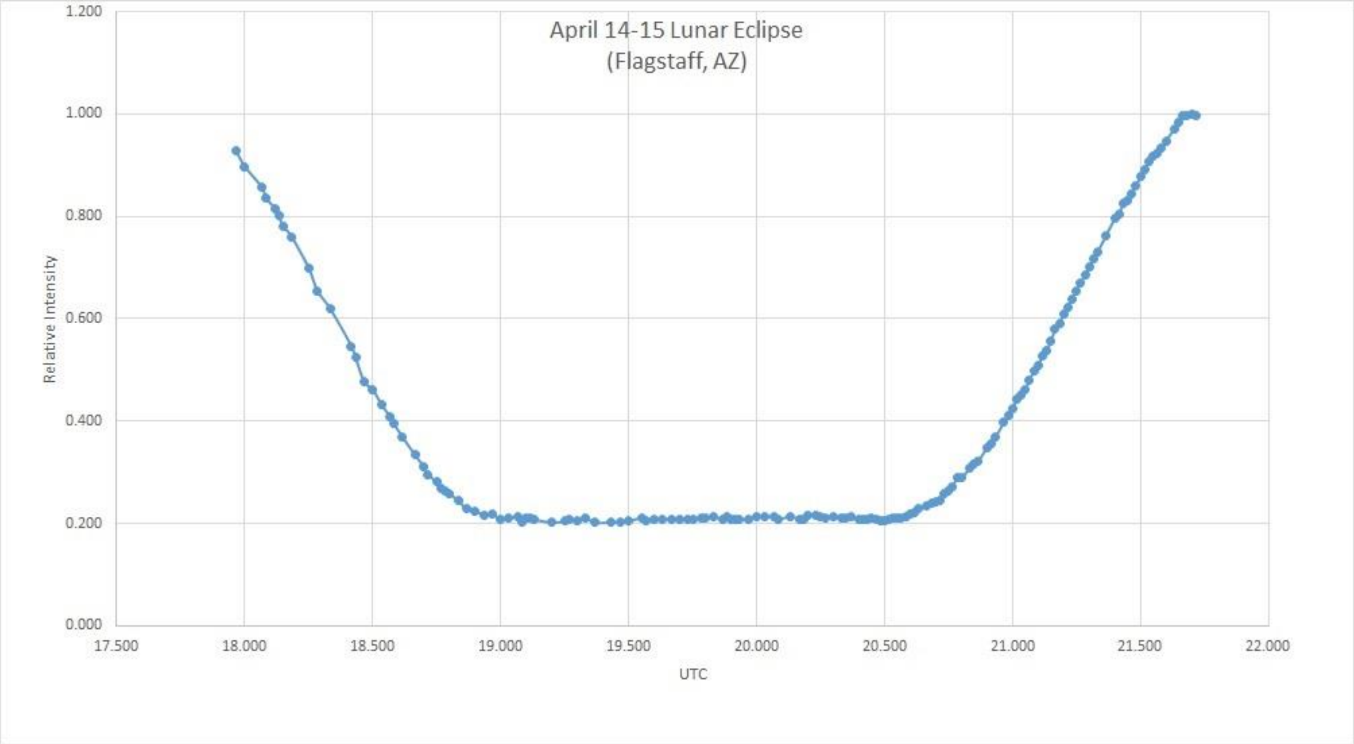
Note the microcontroller provides power (red) and ground (white) and accepts input via the signal (yellow) line



A brute force, very basic, ‘sketch’ to read signal levels.

Lunar Eclipse Measurements

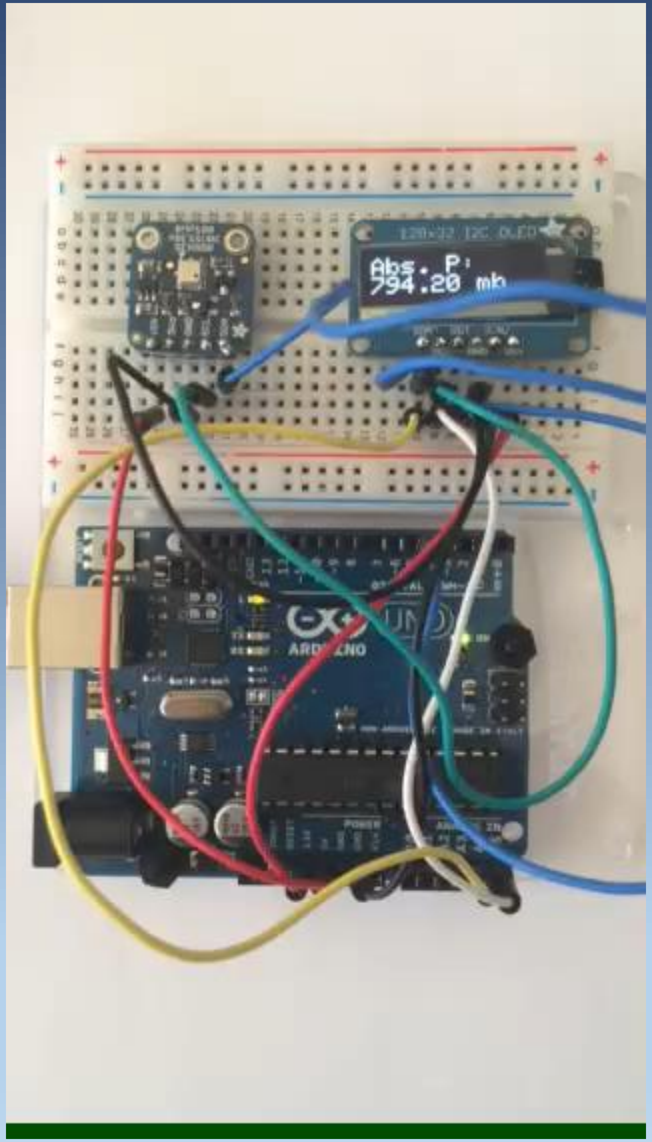




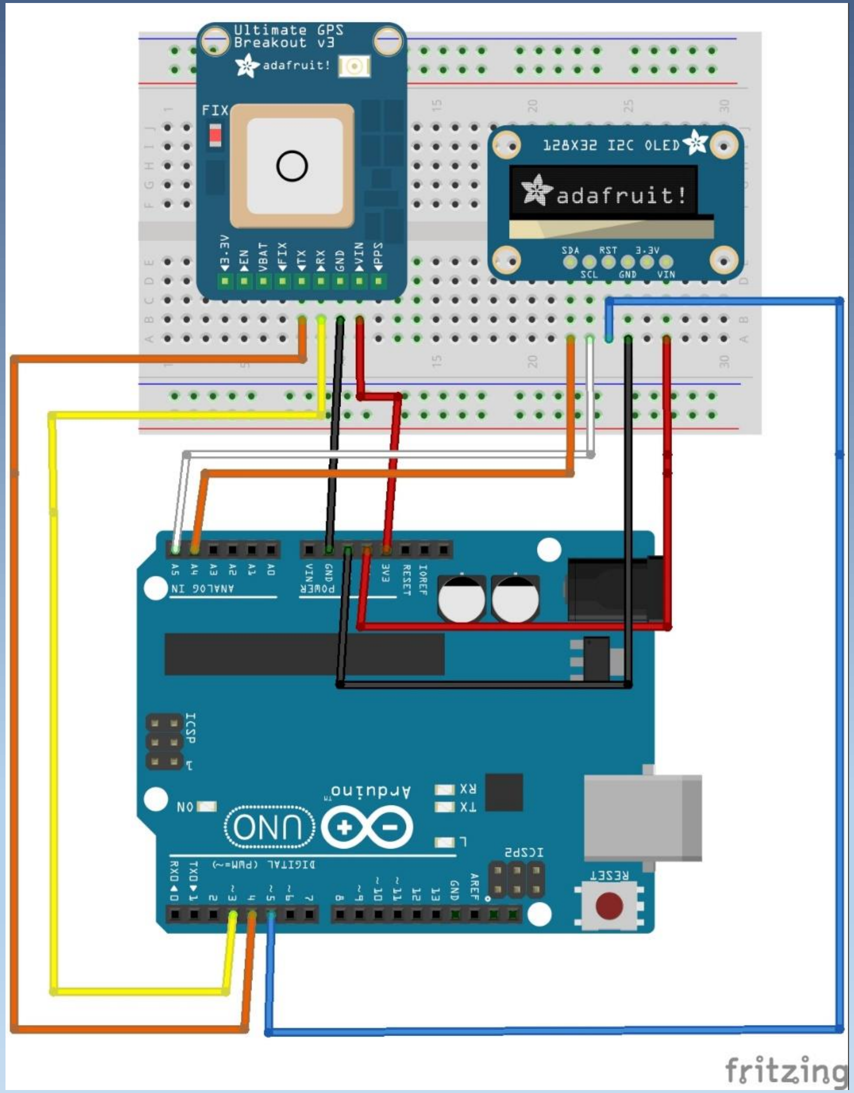
Simple experiments can be very effective!

More complex sensors

- Expertise encapsulated in the form of free, downloadable, software libraries
- No need to re-invent the wheel
- Use library-supported commands to talk to GPS units, accelerometers, motion and rotation detectors, digital pressure and temperature sensors etc.
- Easily talk to digital displays!



GPS Systems...

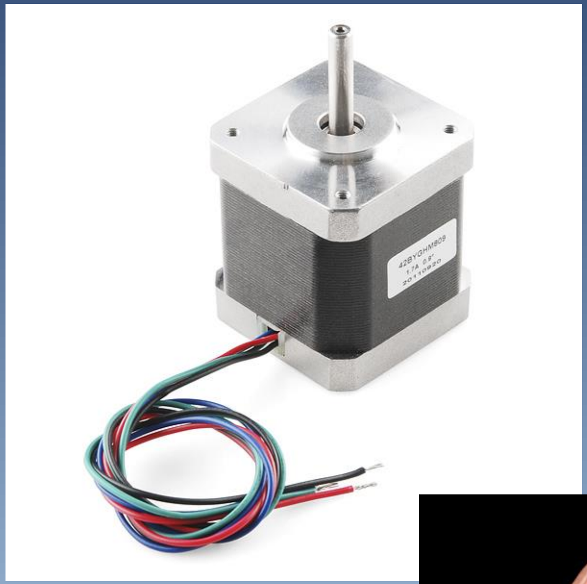


Ultimate GPS
Breakout v3
adafruit!
FIX
3.3V
EN
VBAT
FIX
TX
RX
GND
VIN
PPS
128X32 I2C OLED
adafruit!
SDA
RST
3.3V
SCL
GND
VIN
ANALOG IN
POWER
RESET
ICSP
Arduino
UNO
RX
TX
DIGITAL (PWM=~)
ICSP2
RESET
AREF
GND
fritzing

128x32 I2C OLED
SDA
RST
3.3V
SCL
GND
VIN

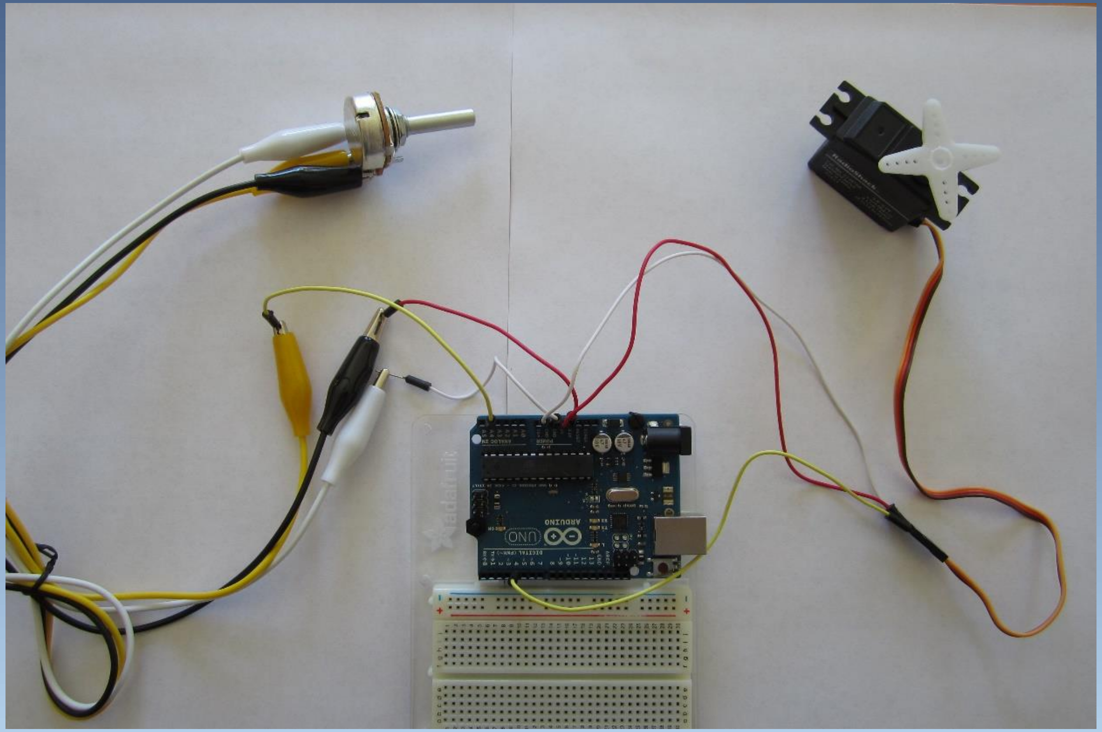
Controlling things…

- Stepper/Servo motors are motors that can be instructed to take a particular orientation based on digital pulses
- Such motors can therefore be controlled remotely using signals instead of using cables, pneumatics, or hydraulics



Demonstrating fly-by-wire technologies

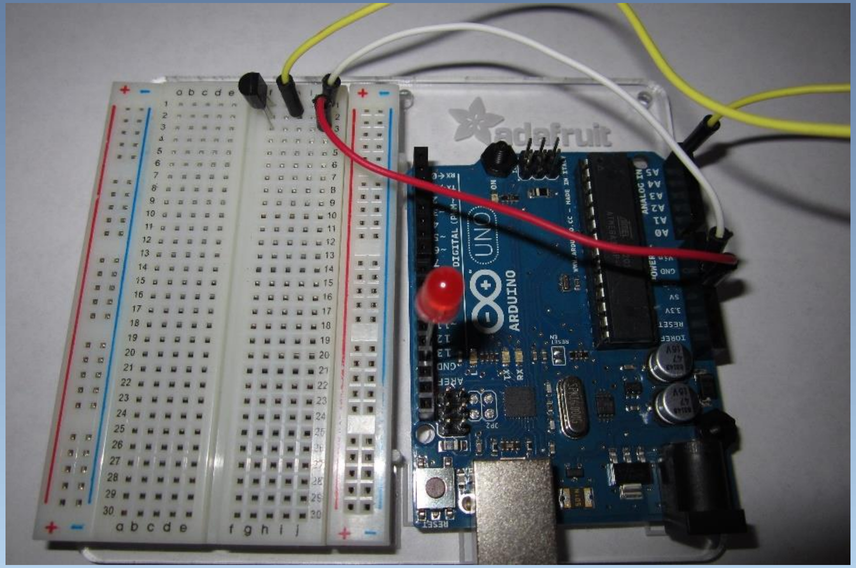
- Use a potentiometer to input rotation
- Use the microcontroller to set stepper motor position angle
- We could control a control surface such as an aileron by adjusting the potentiometer.



Decisions and Thresholds

What if we want events conditional upon physical parameters such as temperature?

To turn on hanger heat, or de-icing equipment, or to automatically activate fire alarms?



The red LED illuminates when the temperature sensor’s Signal exceeds a programmed threshold.

Working with high voltage

- If I can activate an LED, I can turn on or off any device, fire alarm, electronic door, and operate relays.

A power-switch like this accepts low voltage, optically isolated, control signals allowing them to activate high voltage (up to 15Amp) circuits safely.

Possible skills and activities

- How to write computer codes
- Designing projects that rely on various sensors
- Have students build their own flight black-boxes?
- Build weather stations?
- Build density-altitude displays?
- Collect data to study weather cycles
- Analyze communication channel capacity and usage patterns
- Acoustic studies using microphones as sensors
- How to capture sensor data
- How to implement remote control of motors and devices

Terminology and technology exposure

Sensors/ Devices

- GPS, temperature, pressure, light detecting, force-strain, rotation, acceleration

Electrical

- voltage-dividers, relays, switches, voltage, current, resistance, potentiometers

Computer based technology

- Analog-to-Digital Converters, protocols, libraries, digital displays, pulse-width-management, signals, I2C protocol

Engineering/Mechanical:

- Servos, motors

Benefits/Summary

- Aviation students can use microcontrollers to learn about technologies that underlie fly-by-wire and glass cockpit solutions
- The wide hobbyist and college user-base provides ready access to existing core solutions
- Microcontrollers are cheap and easy to integrate into the classroom environment
- They do provide opportunities for interesting projects to motivate and develop student appreciation of modern aircraft technologies and support in-class teaching and provide opportunities for senior-thesis types of projects.

CARACTERISTICAS DEL TELESCOPIO

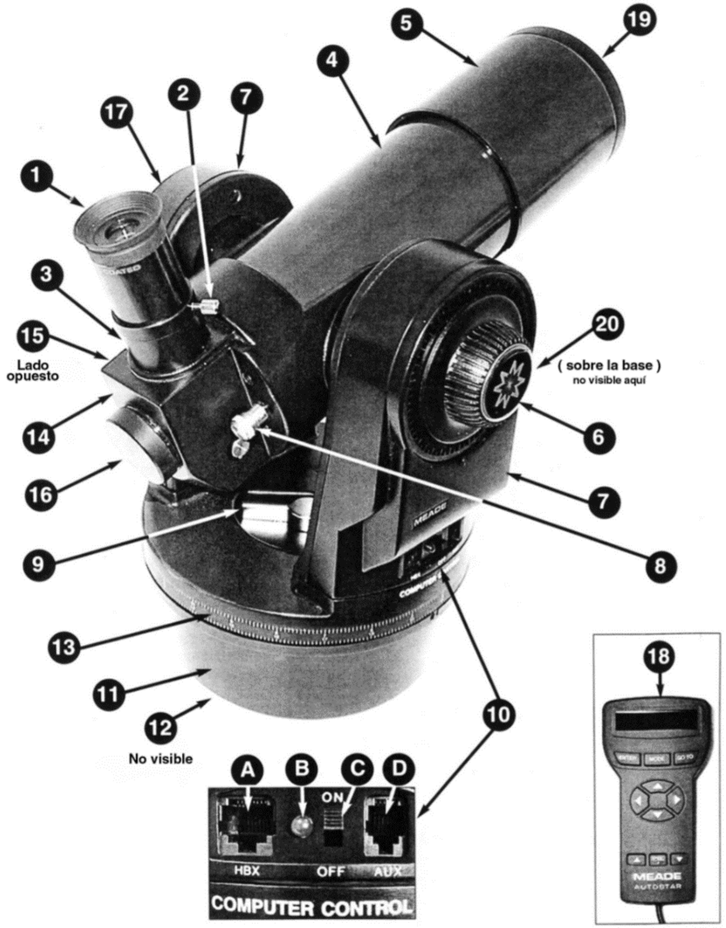
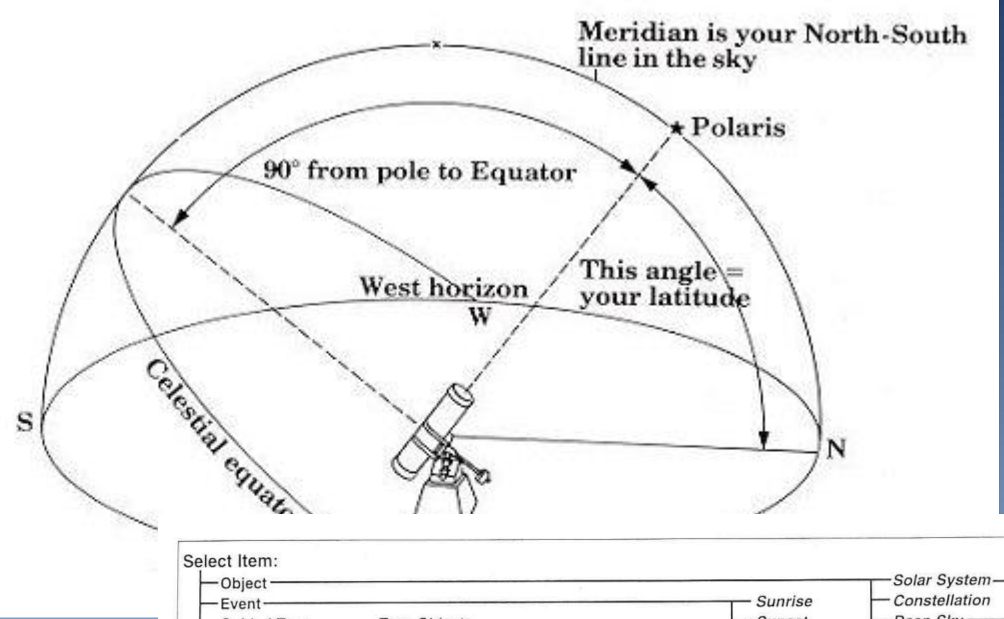


Figura 1: El Telescopio ETX-60AT y ETX-70 AT



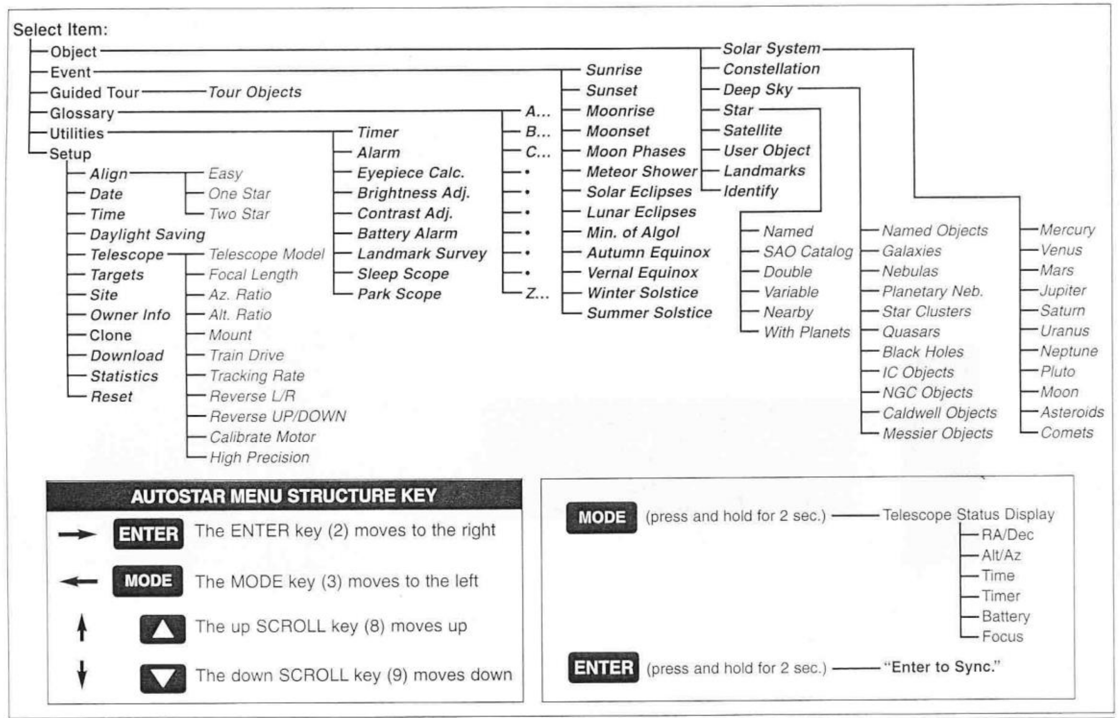


Fig. 1: Autostar Primary Menus and Options.