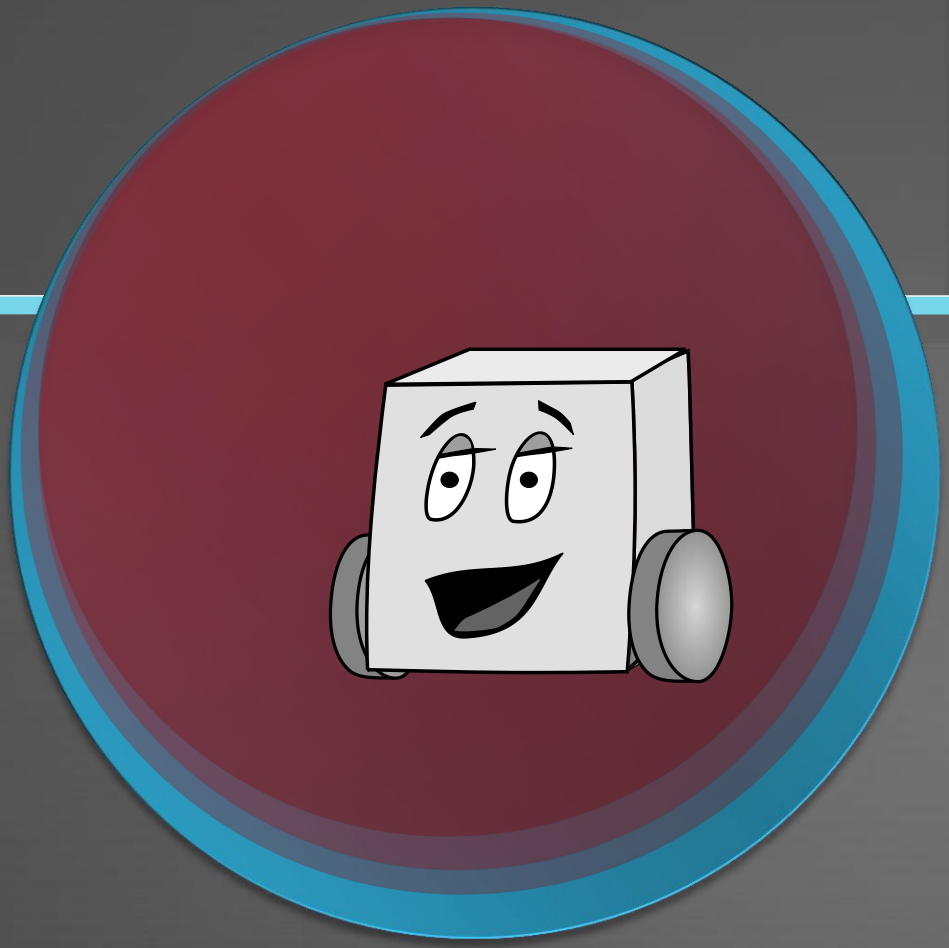


E11 Lecture 5: Design Representation

Profs. David Money Harris & Sarah Harris

Fall 2011

Outline

- Mechanical Design Representation
  - Orthographic Projections
  - Isometric Projections
  - Computer-Aided Design (CAD)
  - Computer-Aided Manufacturing (CAM)
  - Autonomous Vehicle Chassis
- Electronic Design Representation
  - Schematic Elements
  - Mudduino Schematic

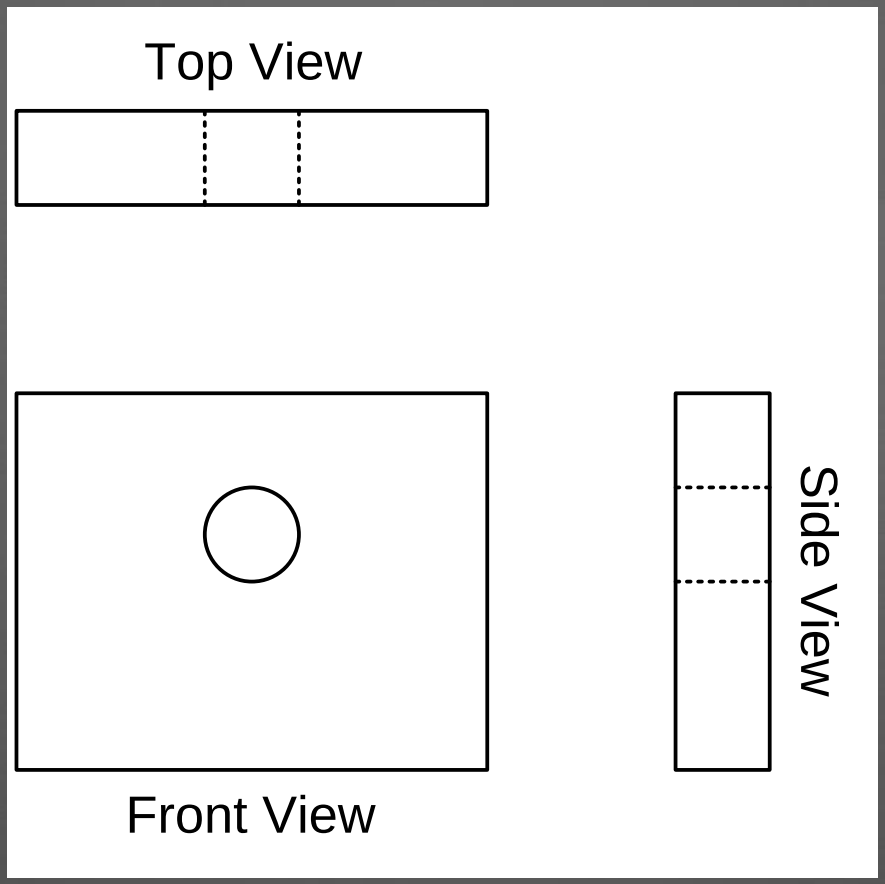
Design Representation

- How to represent a 3-dimensional object on a 2-dimensional page?
- Projections
  - Orthographic
  - Isometric

Orthographic Projection

- Front, top, and side views
- *orthos* "straight" + *graphic* "drawing"
- Used by Greek and Roman astronomers and engineers

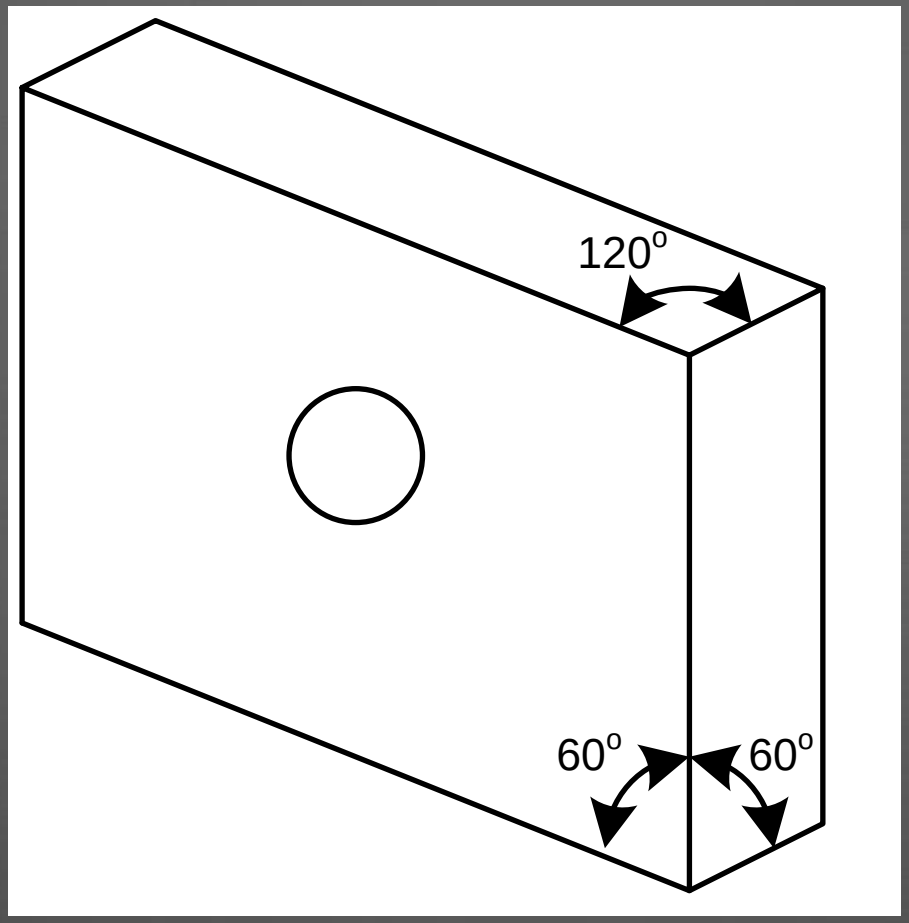
Orthographic Projection



Isometric Projection

- Shows three faces all at once
- Preserves distances accurately along each axis
- Angles between each axis are 120 degrees
- *iso* = "equal" + *metric* = "measure"

Isometric Projection



Example: I-beam

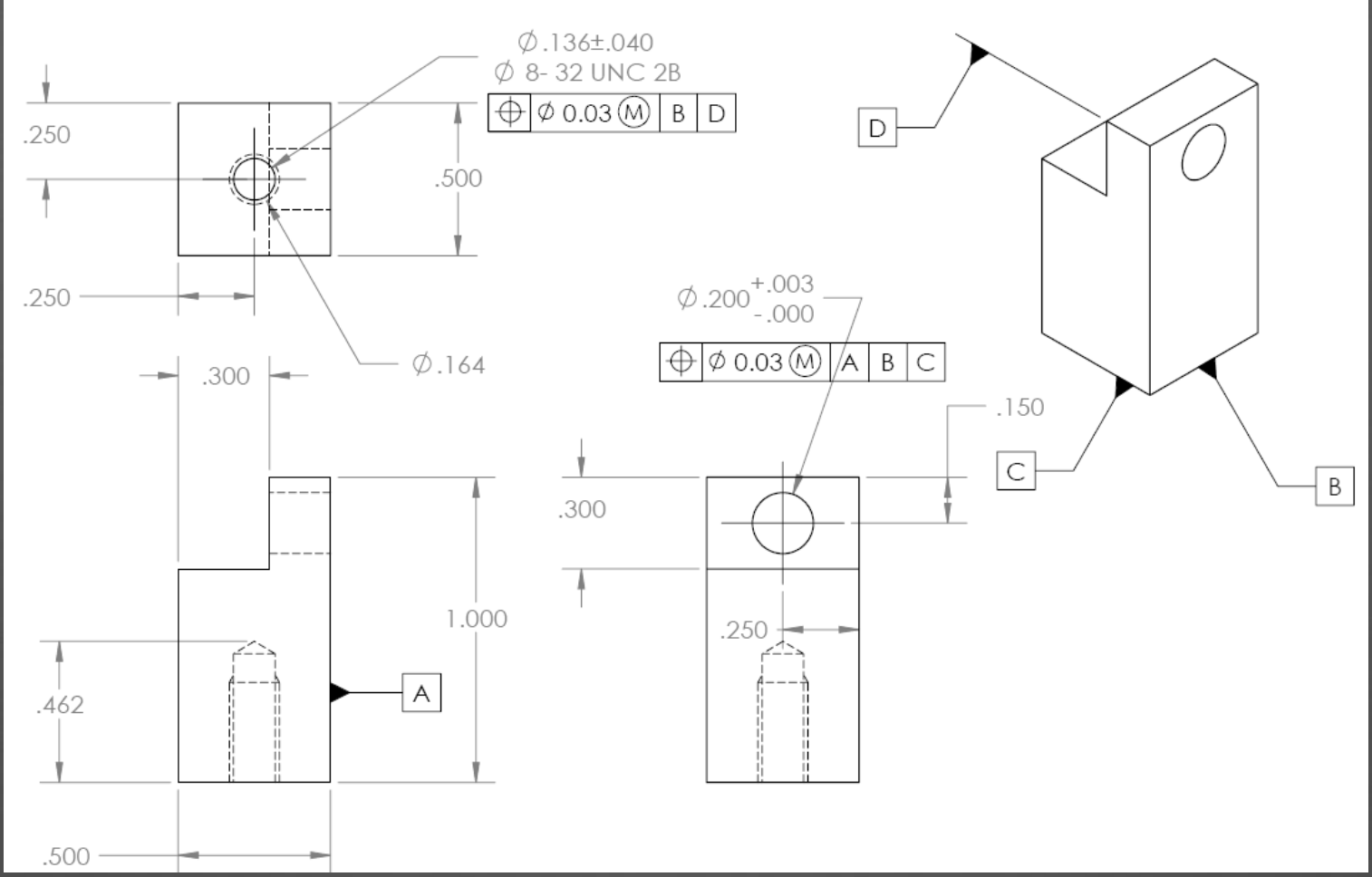
Datum Features

- Datum features are used to align the part
  - Make measurements from a consistent edge
- Feature labeled "A" is the *primary datum*
  - Align the part to this edge whenever possible
  - Keep it flat against a vice during maching
- Features "B" and "C" are *secondary* and *tertiary* datum

Dimensioning

- Dimensions are measured from the datum features
  - Only a minimum necessary set are shown
  - If a dimension isn't labeled, it is implied by symmetry
- Often you will need to make calculations
  - Mark up the drawing to make your life easier in the shop
- Holes are specified by their diameter (∅)
- Some dimensions have tolerances shown

Example: Sensor Tower



Computer-Aided Design

- CAD software has replaced the drafting table
- HMC primarily uses SolidWorks
  - World's leading CAD tool
  - Relatively easy to use
  - Easy integration with simulation and manufacturing

SolidWorks Concepts

- Sketches
  - 2D shapes such as lines, circles, text
  - Must be fully dimensioned
- Features
  - 3D objects built by extruding or cutting sketches

Computer-Aided Manufacturing

- Automate manufacturing from CAD drawings
  - 3D printing
  - Computer numerical control (CNC) machining

3D Printing

- Additive manufacturing process
- Create 3D object from successive layers of materials
- Primarily use powders or polymers
- Good for models and visualization
- Limited material strength

Dimension ST1200 3D Printer

- Prints with ABS plastic
- Soluble support material
- 10 or 13 mil layers
- 10 x 10 x 12" maximum volume
- $30k machine cost
- $10/in^3 materials cost

3dimensionprint.co.uk

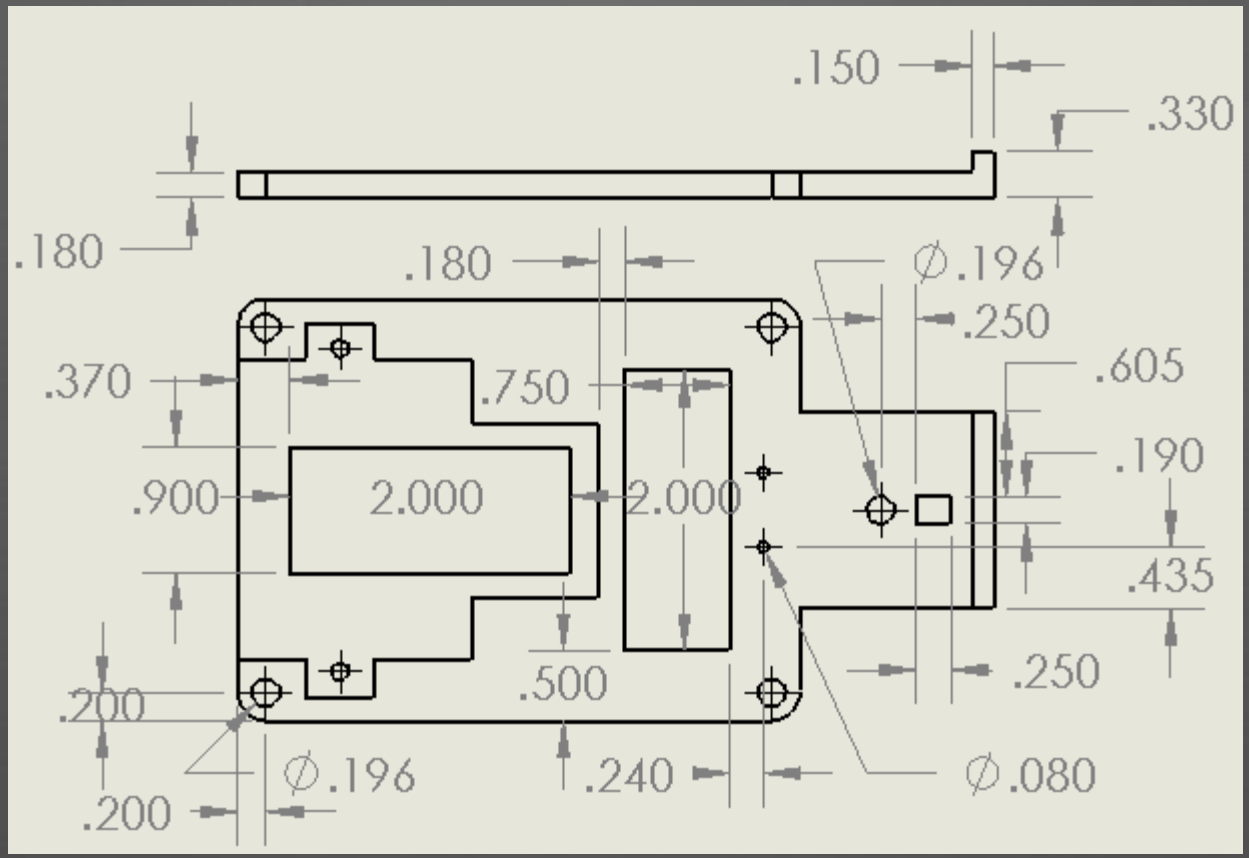
CNC Machining

- Subtractive manufacturing process
- Computer-controlled tool removes material from a piece of stock
- Examples:
  - CNC Mill and Lathe
  - Laser Cutter
  - ShopBot

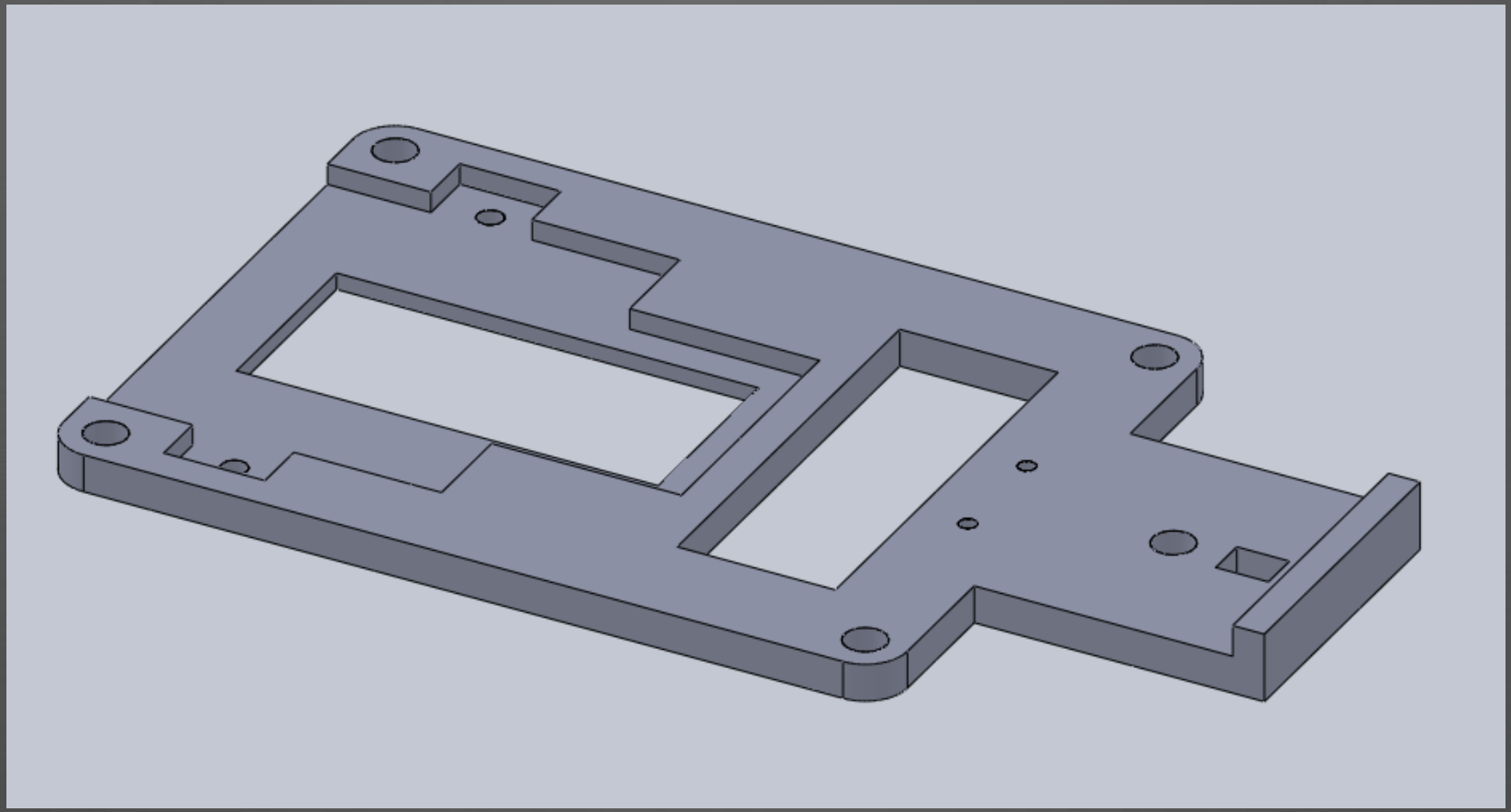
www.cuttingtoolssite.com

Autonomous Vehicle Chassis

- Lab 2: Draw in SolidWorks and 3D print chassis



Chassis Isometric View



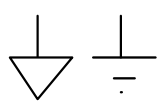
3D Printer Access

- Save your SolidWorks drawing in Stereolithography (.STL) format
- Email .STL file to Willie_Drake@hmc.edu with subject "E11 3D print request for <username>"
- Class covers materials costs for Lab 2 + one additional chassis, up to 2.5 in^3
- You may use the printer for personal projects on a space-available basis at a cost of \$10/in^3 payable to Engineering

Electronic Design Representation

- Schematic describes the connection of electronic components
- Good schematic practices
  - Make the drawing easy to read
  - Use standard symbols
  - Group together related elements
  - Avoid bending lines without a reason
  - Use pins to connect by name where appropriate
- Bill of materials (BOM) specifies purchasing information

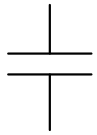
Schematic Symbols



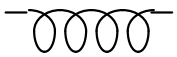
GND
(0 V)

Power
(V_{DD}/V_{CC})

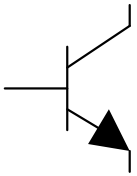
Resistor



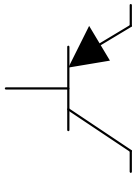
Capacitor



Inductor



npn
transistor

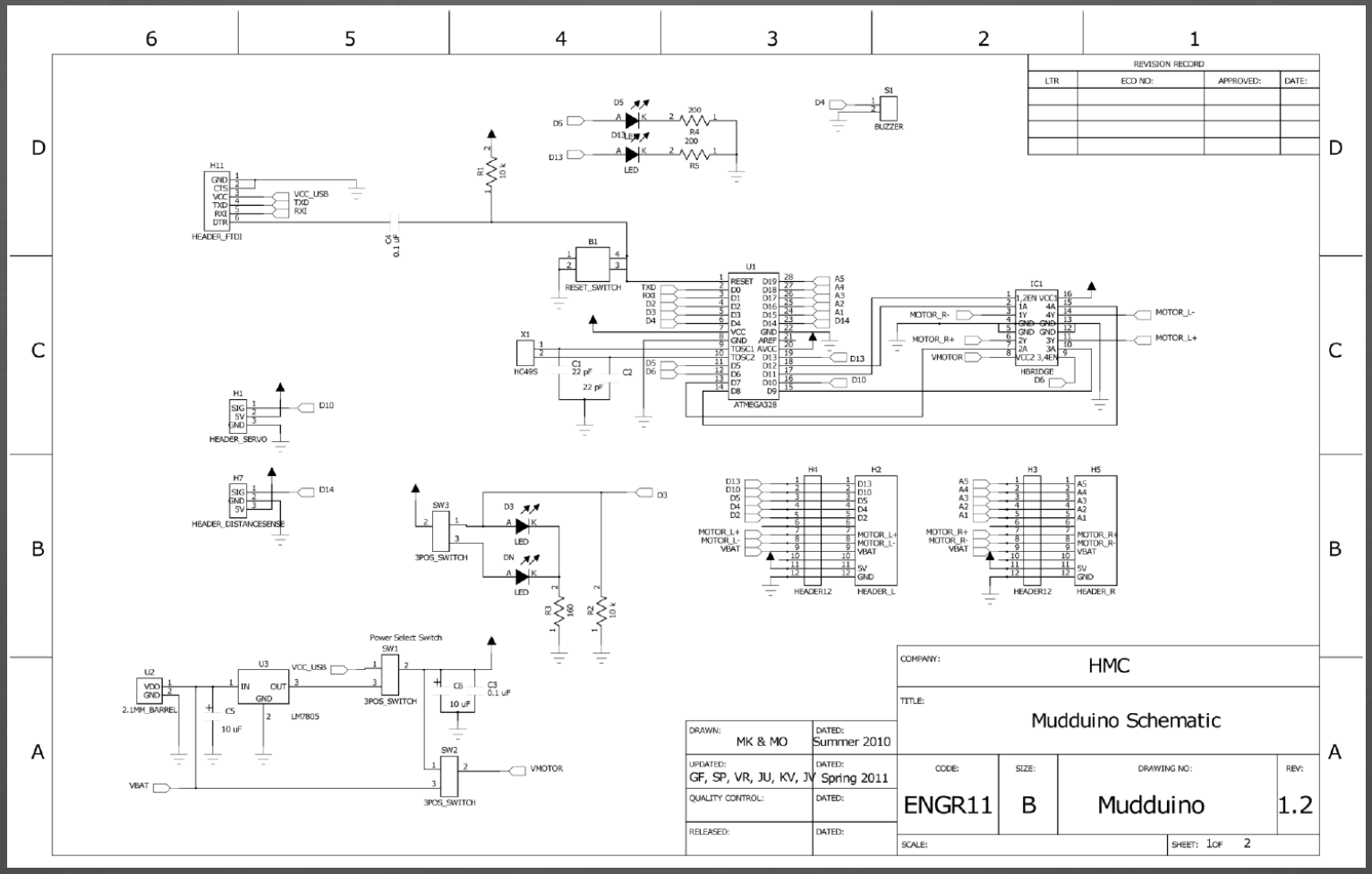


pnp
transistor

Diode

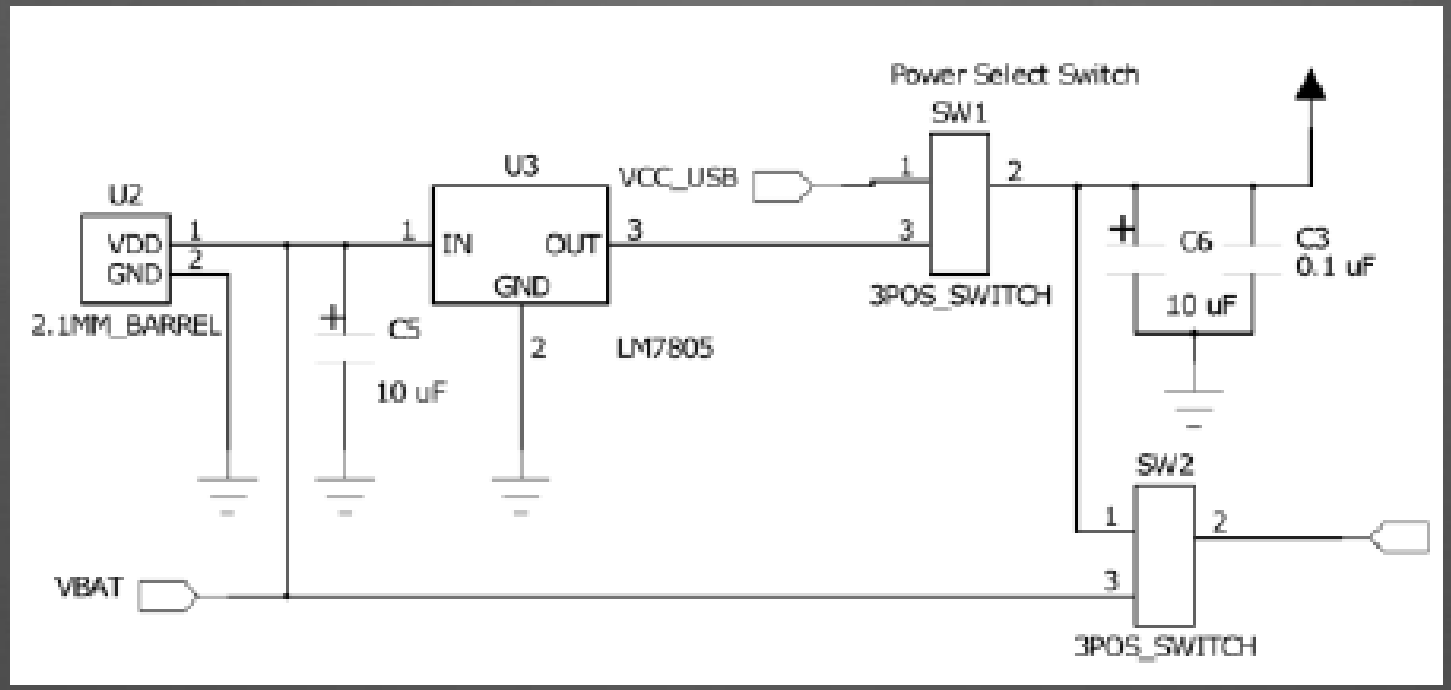
Switch

Mudduino Schematic



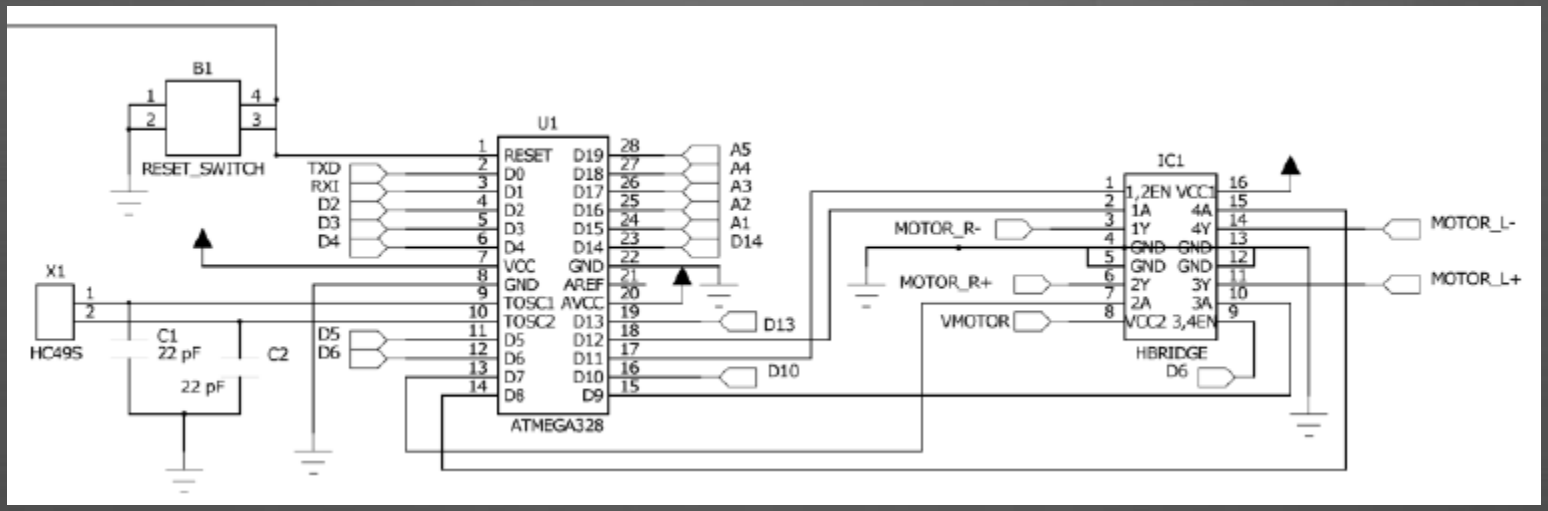
Power Supply

- Battery & USB sources
- Power and Motor switches + Bypass capacitors



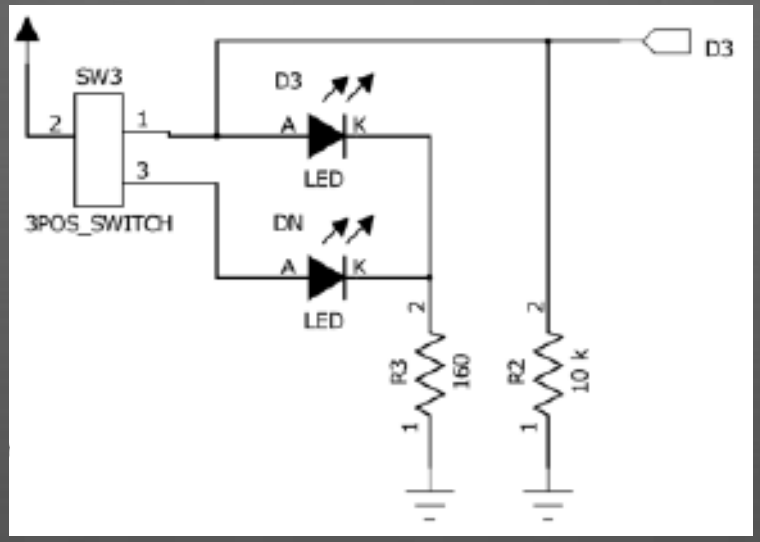
Microprocessor & H-Bridge

- ATMEGA 328 Microprocessor
- H-Bridge Motor Driver
- Oscillator & reset switch



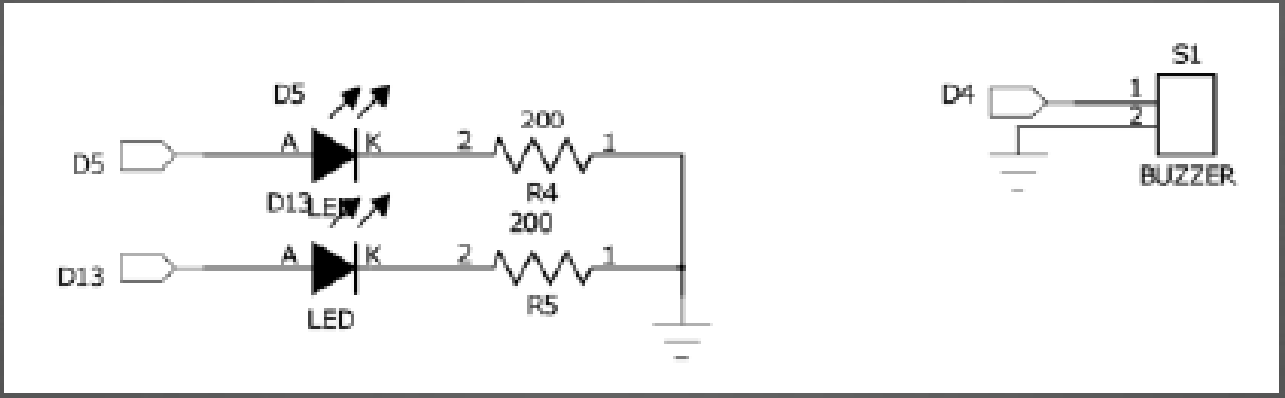
Team LED

- Switch to select team
- Two LEDs to indicate team
- D3 reports team to processor



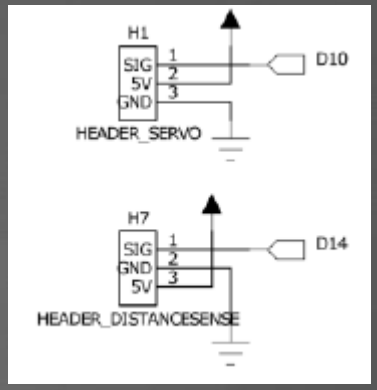
LEDs and Buzzer

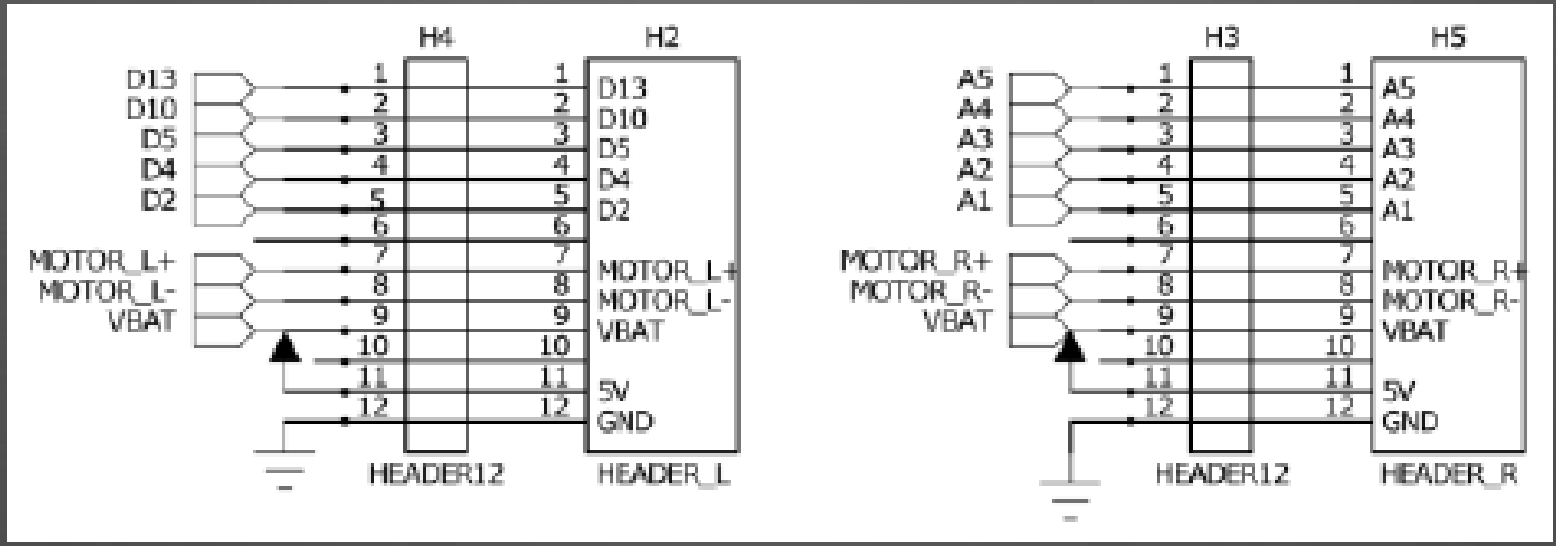
- D5 and D13 drive LEDs
- D4 drives buzzer



Header Pins

- Left and right:
  - Analog/Digital I/O, Motors, V_{bat}, 5V, GND
- Servo and distance sensor (D10 / D14)





FTDI Connector

- Serial transmit and receive data (TXD, RXI)
- 5V and GND, limited to 500 mA
- Reset pulse after programming