Week 7 - introductory electronics (2)

PREP WORK

1. Gather soldering equipment for each student
    - Stations or soldering irons
    - PCB vises and/or helping hands
    - Solder
    - Brass or wet sponge
    - Needlenose pliers and diagonal cutters
2. Gather materials for each student for ***soldering activity***
    - 8-pin DIP IC sockets
    - Perfboards
3. Gather circuit boards for show-and-tell
    - Jar of Fireflies, MaKey MaKey, openSip+Puff, consumer electronics
4. Create and print out perfboard layout guide for soldering activity.
5. Create and print out enough handouts containing sources for learn-to-solder kits
6. Bring in or acquire external LCD screen to demonstrate PCB design to class

Outline

1. *Discussion of Curiosity Handbook work since last class session*
2. Introduction to soldering - what it is, why it's important, tools and how-to
3. *Soldering activity* - soldering last week's 555 timer project onto perfboard
4. Overview of circuit boards (PCBs) - how they are made and why they are important
    a. Show and tell of various circuit boards, including personal projects
5. Going further with PCBs - finding and buying circuit board kits

Introduction to soldering

1. What is soldering - method of connecting electronics components together using molten metal
2. Why it's important - allows us to create circuits that don't fall apart. It is also one of the necessary techniques involved in manufacturing electronics.
3. Tools
    a. *Soldering iron* - bare iron that immediately heats up when plugged in. No temperature control
    b. *Soldering station* - allows temperature control
    c. *Solder* - metal with low melting point used for connecting components together
    d. *Sponge (either brass or wet)* - used to clean excess solder from tip of iron
    e. *Helping hands* - positionable alligator clips useful for holding components and wires
    f. *PCB vise* - positionable clamp used to hold circuit boards without blocking access
4. ***Soldering demonstration*** - solder multiple parts to perfboard, demonstrating and discussing proper soldering technique

Soldering activity

1. Distribute tools and parts
    a. Distribute and turn on soldering irons/stations
    b. Distribute solder
    c. Distribute PCB vises or helping hands
    d. Distribute perfboards
    e. Distribute and explain 8-pin DIP IC sockets
2. Set perfboard into vise
3. Place and solder parts
    a. IC socket in center - use tape to secure, solder in place
    b. Place, bend and solder **R1**
    c. Place, bend and solder **R2**
    d. Place, bend and solder **C1**
    e. Place, bend and solder **R3**
    f. Place, bend and solder **LED1**
    g. Add jumper wire to connect IC pins 4 and 8 together
    h. Make sure that all +V lines are connected
    i. Make sure that all GND lines are connected
    j. Solder 9V battery clip to +V and GND lines
    k. Insert 555 timer into IC socket

4. Troubleshooting

    a. Insert 9V battery and watch for puffs of smoke or odd behavior
    b. Verify all connections, paying close attention to +V and GND lines - make sure they are not touching anywhere.
5. Finishing up
    a. Power down and set aside soldering irons
    b. Collect and set aside all tools and materials

Overview of circuit boards (PCBs)

1. Circuit board = a thin piece of material onto which conductive tracks (called *traces*) are printed, electrically connecting components together when soldered.
2. PCB (printed circuit board) = generally synonymous with “circuit board”
3. Why they are important - allow us to mass-produce circuits, as well as create much more complicated designs without the worry of also having to wire up every component ourselves (thus reducing problems).
4. How they work
    a. *Illustrate composition of PCB* - FR4 substrate, copper, soldermask, silkscreen
    b. *Traces* - lines of copper connecting components according to schematic. Laying out traces efficiently can be a very complex and difficult task requiring very thorough understanding of signals and power flowing through every part of the board.
    c. *Pads* - exposed areas of circuit board onto which components can be soldered
    d. *Vias* - holes that connect different sides or layers of the circuit board together. Must be *plated* to conduct electricity through the hole.
    e. *Multiple sides and layers* - most common to have two sides for circuit board, but more complex circuit boards can contain 4, 6 or even 16 or more layers for routing traces and managing heat!
    f. *Surface mount technology (SMT)* - the parts we have used so far are called “through-hole” (for obvious reasons) and still require humans to solder onto boards. However, all of these components also have surface-mount versions that can be placed onto just one side of a circuit board (with no holes) by machine and soldered automatically by another machine.
5. How they are made
    a. *Schematic* - created in CAD
        i. Easy and cheap = 123D Circuits, Fritzing and KiCAD
        ii. Intermediate (to advanced) and reasonably priced = EagleCAD
        iii. Hard and expensive = Altium Designer
    b. *Circuit board layout* - must generally be done manually in CAD
        i. Components and their connections are automatically generated and associated with schematics.
        ii. Traces must then be routed manually, like a puzzle.

iii. Auto-routing software does exist, but so for it has not yet surpassed the capabilities of a skilled human.
iv. Serious skill required for serious circuits, but basic circuits are not necessarily serious. Try!

c. *Fabrication* - creation of the bare circuit boards
   i. Can be done chemically by “etching” with acid, or mechanically using CNC technology.
   ii. DIY options do exist, but require handling very dangerous chemicals, semi-specialized equipment and a safe working environment.
      1. Boards can also be CNC milled, but are much more limited than traditional boards due to lack of ability to easily do two-sided PCBs.
   iii. Best to have PCBs professionally made through services such as OSHPark, Seeed Studio and iTead Studio.
d. *Assembly* - placing and soldering components onto the board
   i. Easy and free = most PCB components can be soldered by hand with practice, but not all.
   ii. Intermediate and relatively cheap = using a stencil, solder paste can be applied to a circuit board and components then stuck into their correct places. Special ovens called “reflow ovens” then “bake” the board, melting the solder paste and soldering all components at once. This can be done DIY, but is not necessarily beginner-friendly.
   iii. Hard and expensive = components can be soldered onto boards for you by many PCB manufacturers, but be aware that there is a large difference in cost when using surface-mount vs. through-hole parts.

6. Show and tell examples

Going further with PCBs

1. Distribute printed handouts