Day 3
Lab Notes
Lab Notebooks

These are perfect.
The 9x7 size fits well on the lab desks.
Lab Notebooks

This will also work
Protoboards

Aka ‘Breadboards’
Protoboards

Bus strips, or “Rails” are connected (although not necessarily across the full board)

Connect these to your supply voltages
Protoboards

Terminal strips are connected on each side of the gutter
Use these for your components
Data Sheets

Identical part numbers will have identical pin assignments
Protoboards
Our Equipment

Banana Terminals (connect to power supply)
Run wires from terminals to rails

Ground (Earth)

Fixed voltage
Adjustable voltage
Always verify that something works!
Jumper Wires

Great for power connection

Great for connecting to blue box
Removing ICs

TURN OFF THE POWER!!!

Use IC extractor (or screwdriver) to ‘pop’ the IC out of the breadboard
Probably easiest to remove with your fingers after

If you bend the pins, gently bend them back
If you shear a pin, or find an IC that doesn’t work, ask Rudy
TTL Logic Levels

Acceptable TTL gate input signal levels

<table>
<thead>
<tr>
<th>High</th>
<th>5 V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 V</td>
</tr>
<tr>
<td>Low</td>
<td>0.8 V</td>
</tr>
<tr>
<td></td>
<td>0 V</td>
</tr>
</tbody>
</table>

Acceptable TTL gate output signal levels

<table>
<thead>
<tr>
<th>High</th>
<th>5 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_{cc} = 5 V</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.4 V</td>
</tr>
<tr>
<td></td>
<td>0 V</td>
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</tbody>
</table>

Output more restrictive than input - noise suppression
May not actually get 5V out!

Unconnected TTL inputs float “HI”
NEVER connect multiple logic outputs together!

This shows “standard” TTL, which is quite old.
Most of our chips output closer to 5V than this!
CMOS Logic Levels

CMOS -> TTL works fine
TTL->CMOS may not (2.7V TTL HI < 3.5V CMOS HI)

3.3V CMOS also common
3.3V CMOS -> TTL works!

There are also TTL-compatible CMOS chips (HCT family)
# Logic Level Zoo

<table>
<thead>
<tr>
<th>5V CMOS (HC AHC AC)</th>
<th>5V TTL TTIlin / CMOSout (ACT, HCT AHCT)</th>
<th>5V TTL (STD H, LS HS, ALS)</th>
<th>3.3V TTL &amp; CMOS (LV, LVT ALVT LVC, ALVC)</th>
<th>2.5V TTL &amp; CMOS</th>
<th>1.8V CMOS (AVC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vcc</td>
<td>Vcc</td>
<td>Vcc</td>
<td>Vcc</td>
<td>Vcc</td>
<td>Vcc</td>
</tr>
<tr>
<td></td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>3.30</td>
<td>2.50</td>
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<tr>
<td>Voh</td>
<td>4.44</td>
<td>4.44</td>
<td>2.40</td>
<td>2.40</td>
<td>2.30</td>
</tr>
<tr>
<td>Vih</td>
<td>3.50</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>1.70</td>
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<tr>
<td>Vt</td>
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<td>0.80</td>
<td>0.70</td>
</tr>
<tr>
<td>Vol</td>
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<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
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<tr>
<td>Gnd</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Data source: EETimes, A brief recap of popular logic standards (Mark Pearson, Maxim).
Measuring Levels

Works, but can be cumbersome
Make sure to DC couple input!

Multimeter
Give them time to ‘settle’

Logic Probe
Must power, but easy to use
LEDs work great!