1. **Microcontrollers**
   - Introduction to microcontrollers
   - Arduino microcontroller kit

2. **Sensors and Signals**
   - Analog / Digital sensors
   - Data acquisition
   - Data processing and visualization

3. **GPS and Data Logging**
   - GPS receiver and shield
   - Data logging
   - Visualization of data

4. **Motor Control**
   - Motors
   - Encoders
   - Position control
Why Arduino

- Popular
- Open source
- Low cost
- Large user community
- Easy to use development environment

http://todbot.com/

Courtesy of Tod E. Kurt. Used with permission.
Arduino Hardware

LilyPad (for clothing)
Photos by SparkFun Electronics.

Bluetooth
Photos by SparkFun Electronics.

Boarduino Kit
Courtesy of Adafruit Industries. Used with permission.

USB
Photos by SparkFun Electronics.

DIY
“Stamp”-sized
Photos by SparkFun Electronics.

many different variations to suite your needs

http://todbot.com/

Courtesy of Tod E. Kurt. Used with permission.
**Arduino DueMilanove Microcontroller**

http://www.arduino.cc/

Expandable by stacking add-on modules for data storage, wireless, GPS, audio, motor drive,... etc.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>8-bit ATmega328 (by ATMEL)</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>5V</td>
</tr>
<tr>
<td>Input Voltage (recommended)</td>
<td>7-12V</td>
</tr>
<tr>
<td>Input Voltage (limits)</td>
<td>6-20V</td>
</tr>
<tr>
<td>Digital I/O Pins</td>
<td>14 (of which 6 provide PWM output)</td>
</tr>
<tr>
<td>Analog Input Pins</td>
<td>6</td>
</tr>
<tr>
<td>DC Current per I/O Pin</td>
<td>40 mA</td>
</tr>
<tr>
<td>DC Current for 3.3V Pin</td>
<td>50 mA</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>32 KB (ATmega328) of which 2 KB used by bootloader</td>
</tr>
<tr>
<td>SRAM</td>
<td>2 KB (ATmega328)</td>
</tr>
<tr>
<td>EEPROM</td>
<td>1 KB (ATmega328)</td>
</tr>
<tr>
<td>Clock Speed</td>
<td>16 MHz</td>
</tr>
</tbody>
</table>
Arduino Components

- ATmega328
- Analog Input Pins
- Digital I/O and PWM Output Pins
- Reset Button
- USB Interface
- External Power
- TX/RX LEDs
- USB to Serial UART Interface
- 16 MHz Clock
- In-Circuit Serial Programming
- ATmega328
- Power Pins
- Analog Input Pins

Courtesy of Arduino.cc. Used with permission.
Arduino Circuit Diagram

http://www.arduino.cc/

Arduino 2009

9/14/2009

OETL

Courtesy of Arduino.cc. Used with permission.
Open source

Simplified C++ like development environment that is easy to program and to upload the code

Several examples are included that demonstrate various I/O capabilities

Built-in libraries that simplify data I/O tasks

Large user community

Courtesy of Arduino.cc. Used with permission.
Resources

- http://arduino.cc/
- http://ladyada.net/learn/arduino/
- http://todbot.com/blog/category/arduino/
- http://freeduino.org/
- http://adafruit.com/
- http://sparkfun.com/

Books:
- “Arduino Programming Notebook”, Brian W. Evans
- “Physical Computing”, Dan O’Sullivan & Tom Igoe
- “Making Things Talk”, Tom Igoe
- “Hacking Roomba”, Tod E. Kurt
Labs 1 & 2: The Arduino Kit Experiments

Lab 1
- {CIRC01} Getting Started - (Blinking LED)
- {CIRC02} 8 LED Fun - (Multiple LEDs)
- {CIRC03} Spin Motor Spin - (Transistor and Motor)
- {CIRC04} A Single Servo - (Servos)
- {CIRC05} 8 More LEDs - (74HC595 Shift Register)
- {CIRC06} Music - (Piezo Elements)
- {CIRC07} Button Pressing - (Pushbuttons)
- {CIRC08} Twisting - (Potentiometers)

Lab 2
- {CIRC09} Light - (Photo Resistors)
- {CIRC10} Temperature - (TMP36 Temperature Sensor)
- {CIRC11} Larger Loads - (Relays)
# Resistor Color Code Chart

<table>
<thead>
<tr>
<th>Color</th>
<th>1st-band Digit</th>
<th>2nd-band Digit</th>
<th>3rd-band Digit</th>
<th>4th-band Digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>0</td>
<td>$10^0 - 1$</td>
<td></td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>1</td>
<td>$10^1 - 10$</td>
<td>1%</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>2</td>
<td>$10^2 - 100$</td>
<td>2%</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>3</td>
<td>$10^3 - 1000$</td>
<td>3%</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>4</td>
<td>$10^4 - 10000$</td>
<td>4%</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>5</td>
<td>$10^5 - 100000$</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>6</td>
<td>$10^6 - 1000000$</td>
<td></td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td>7</td>
<td>$10^7 - 10000000$</td>
<td></td>
</tr>
<tr>
<td>Gray</td>
<td>0</td>
<td>0</td>
<td>$10^8 - 100000000$</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td>9</td>
<td>$10^9 - 1000000000$</td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td></td>
<td></td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Silver</td>
<td></td>
<td></td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td>20%</td>
</tr>
</tbody>
</table>

**red green brown gold**

250 Ω 5%

Figure by MIT OpenCourseWare.