Introduction to the Hapkit board

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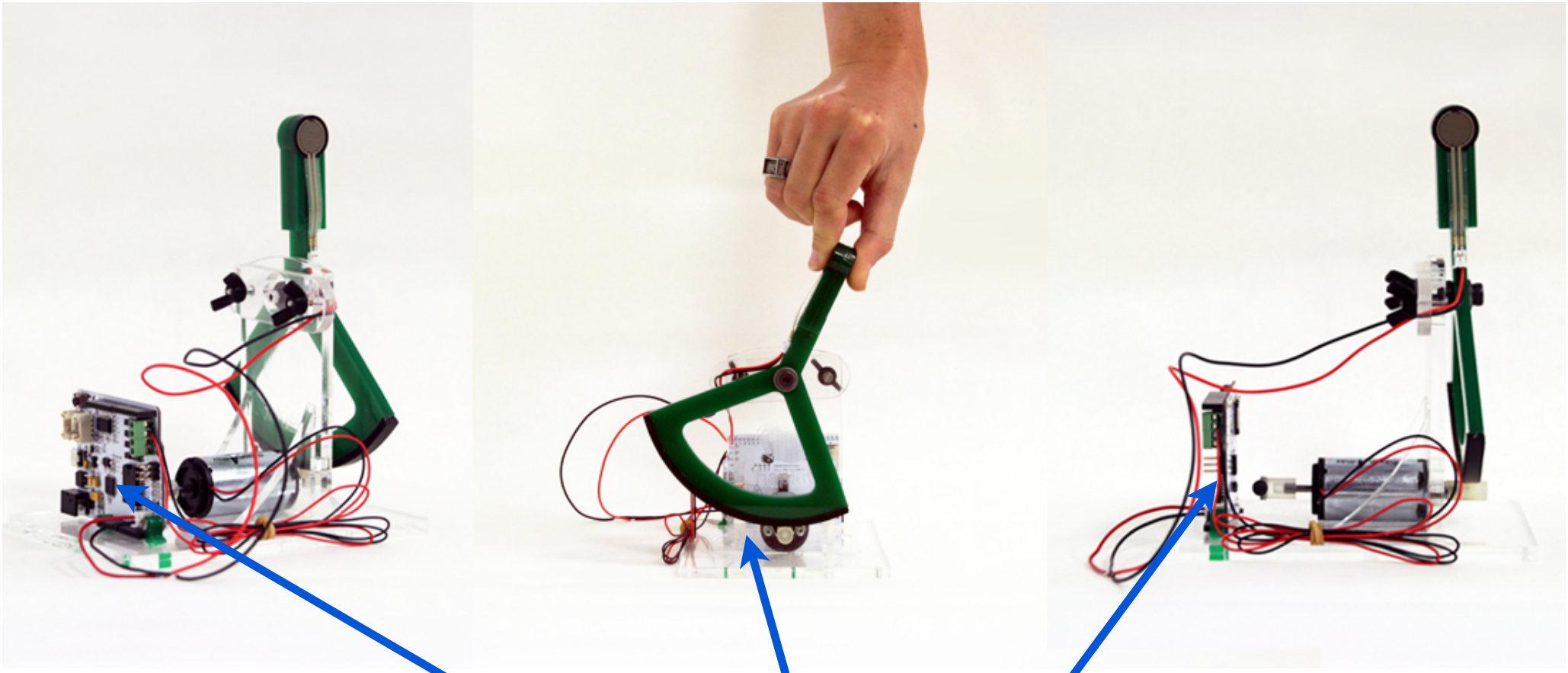
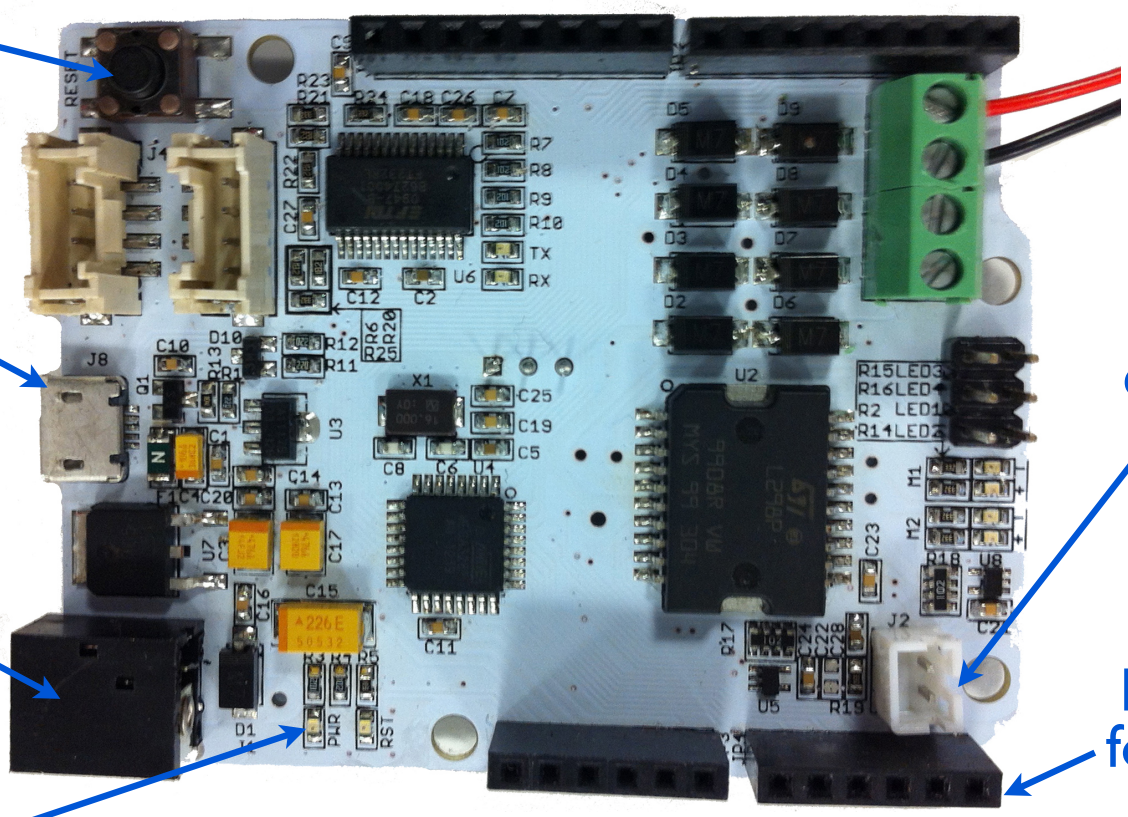
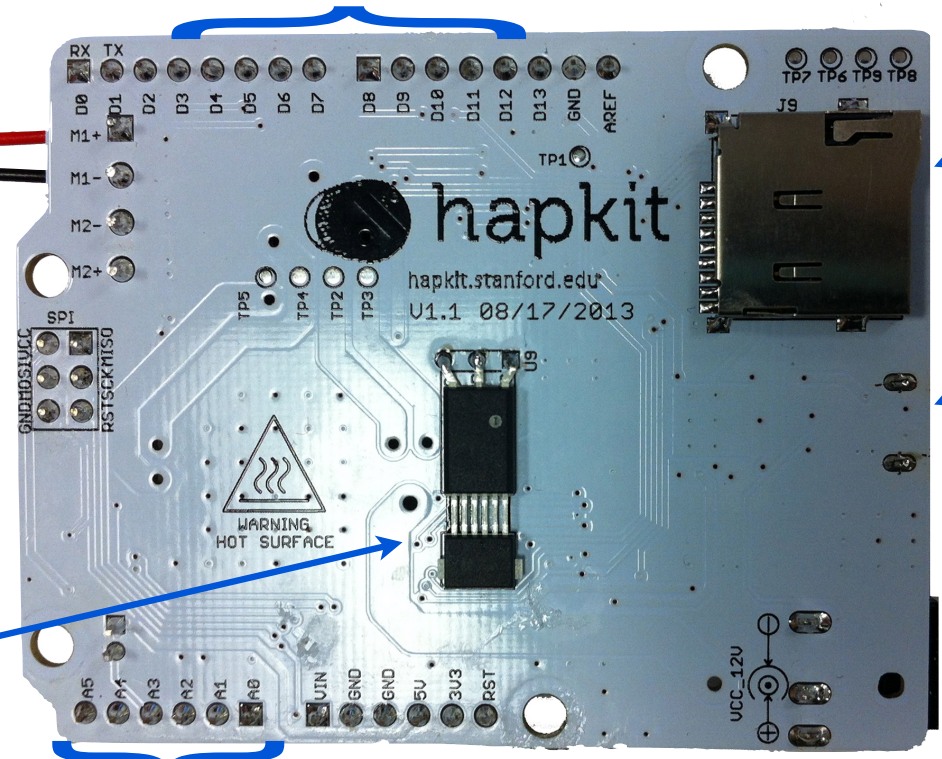


Hapkit board

Hapkit board "front"



Hapkit board "back"



Circuit basics

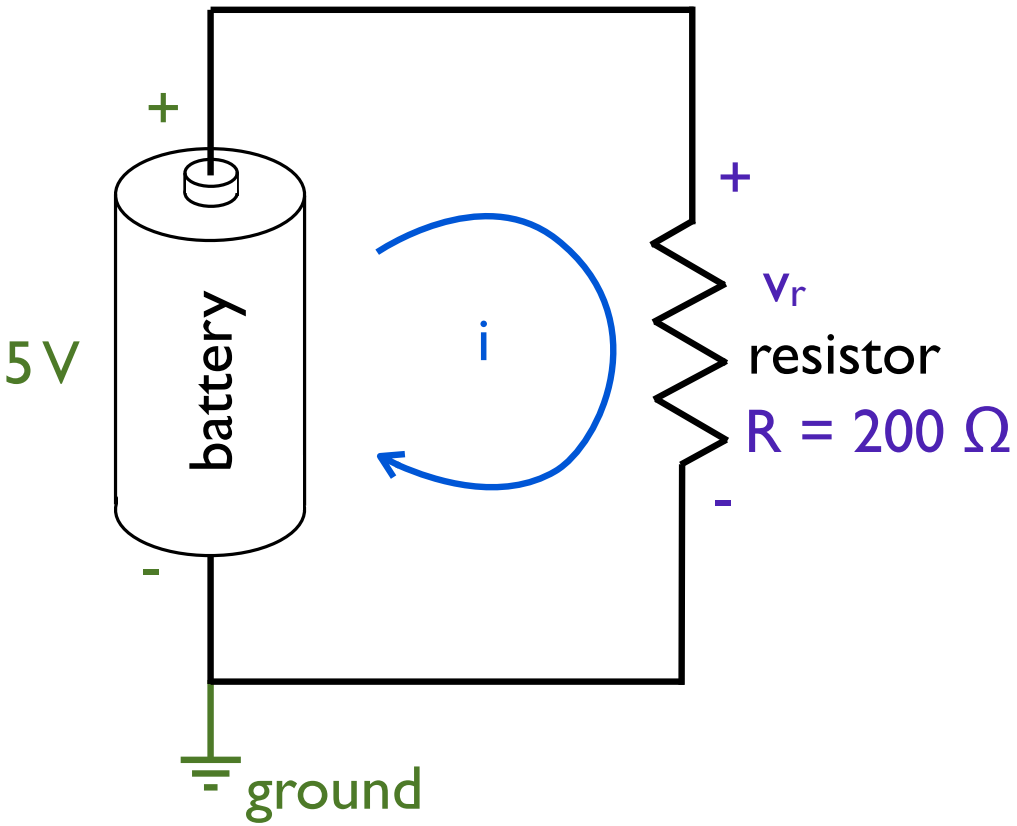
Electric current is a movement or flow of electrically charged particles, typically measured in amperes (A).

Voltage is the electric potential difference between two points, typically measures in volts (V)

Circuit elements such as resistors, capacitors, inductors, and diodes determine the relationship between current and voltage

A circuit needs a **power source** and a **ground** to generate a voltage and induce current.

Example circuit



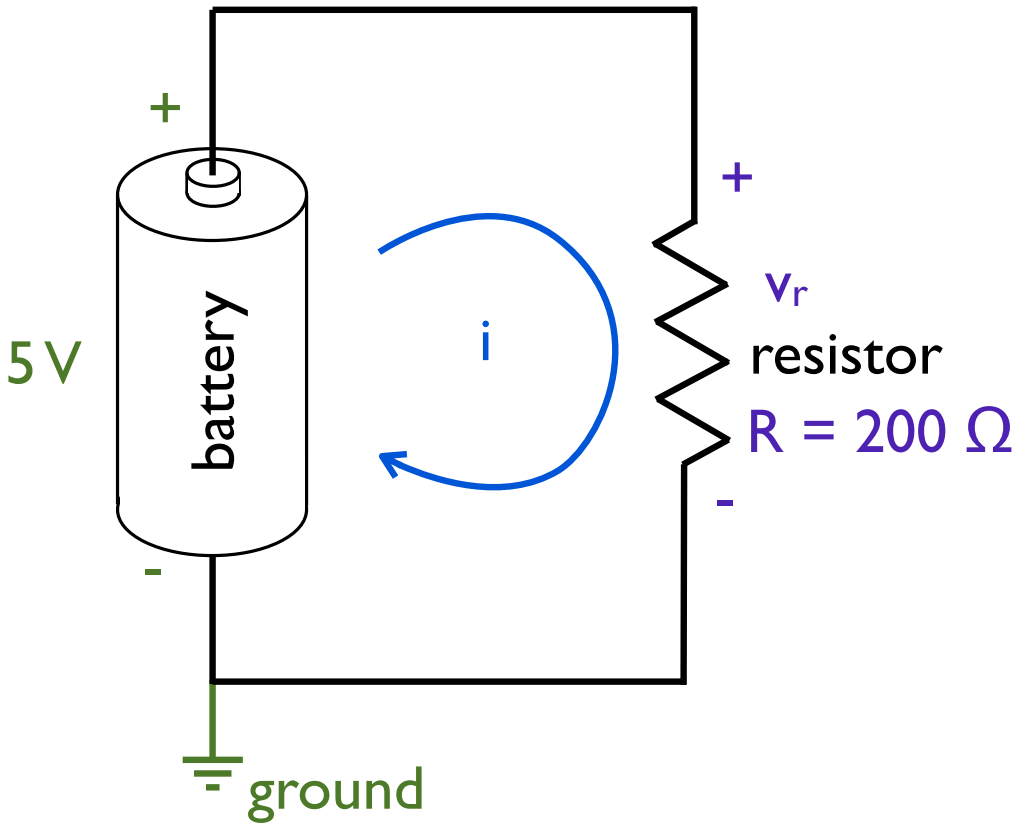
say the battery is a
5 V source

current flows from high
voltage to low voltage

the voltage drop
across the resistor is
computed
from Ohm's law:

$v_r = i\ R$

Example circuit



$$v_r = i\,R$$

$$i = v_r / R$$

$$v_r = 5\,V$$

$$i = 5\,V / 200\,\Omega$$

$$i = 0.025\,A = 25\,mA$$

Resistor values

resistors are usually conveniently marked with colored bands that represent the resistance

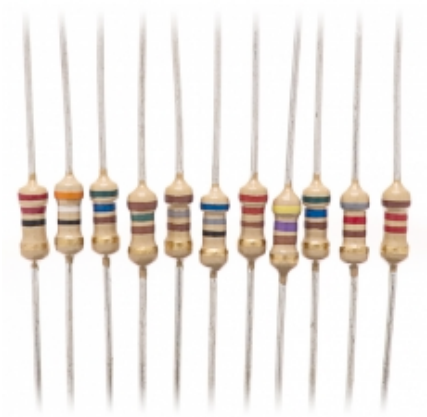
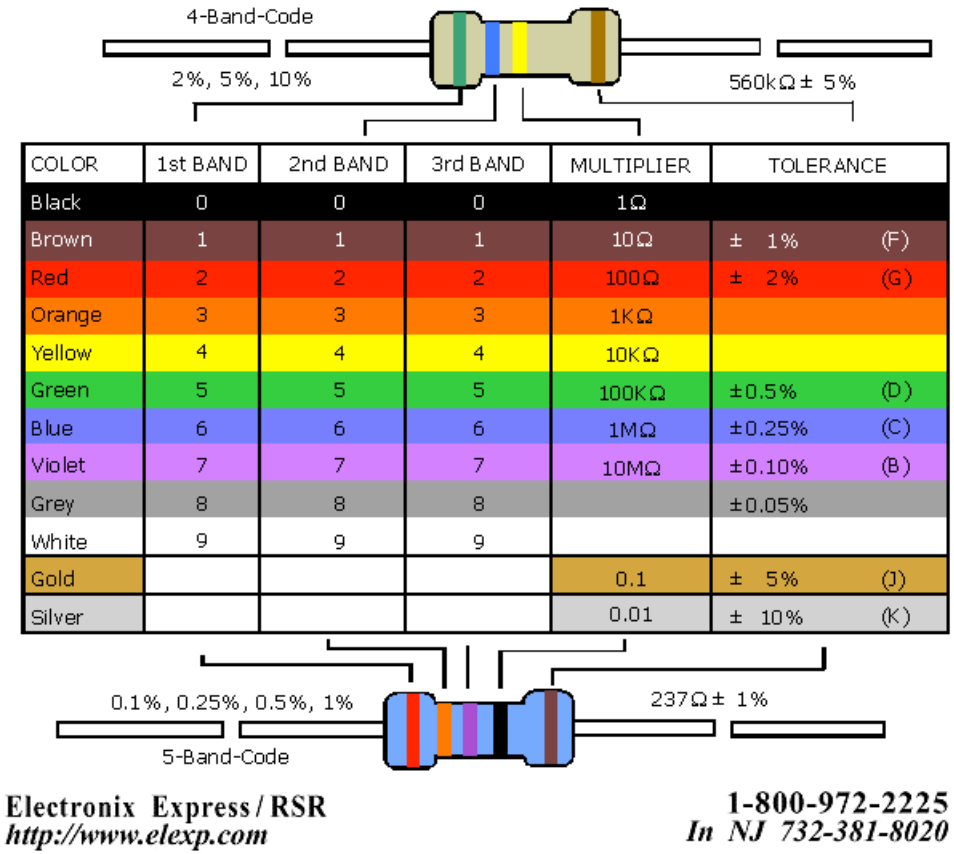


image credit: superbrightleds.com



COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE	
Black	0	0	0	1Ω		
Brown	1	1	1	10Ω	± 1%	(F)
Red	2	2	2	100Ω	± 2%	(G)
Orange	3	3	3	1KΩ		
Yellow	4	4	4	10KΩ		
Green	5	5	5	100KΩ	±0.5%	(D)
Blue	6	6	6	1MΩ	±0.25%	(C)
Violet	7	7	7	10MΩ	±0.10%	(B)
Grey	8	8	8		±0.05%	
White	9	9	9			
Gold				0.1	± 5%	(J)
Silver				0.01	± 10%	(K)

Electronix Express / RSR
http://www.elexp.com
1-800-972-2225
In NJ 732-381-8020

Light-emitting diodes (LEDs)

electroluminescent light source
that is easily integrated into circuits

circuit symbol:

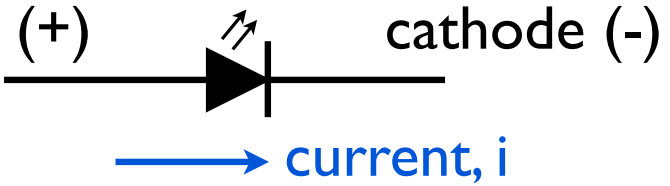
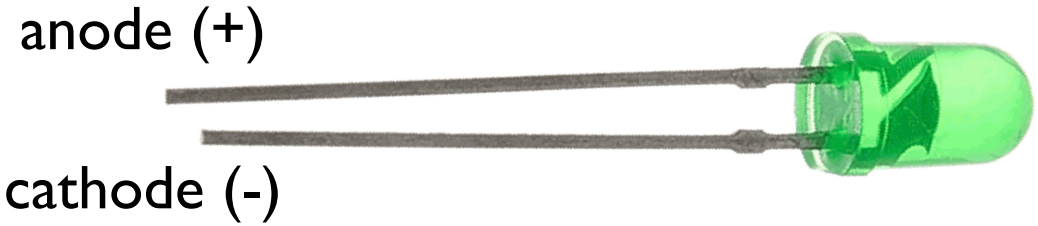
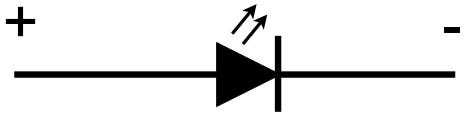


image:



Light-emitting diodes (LEDs)

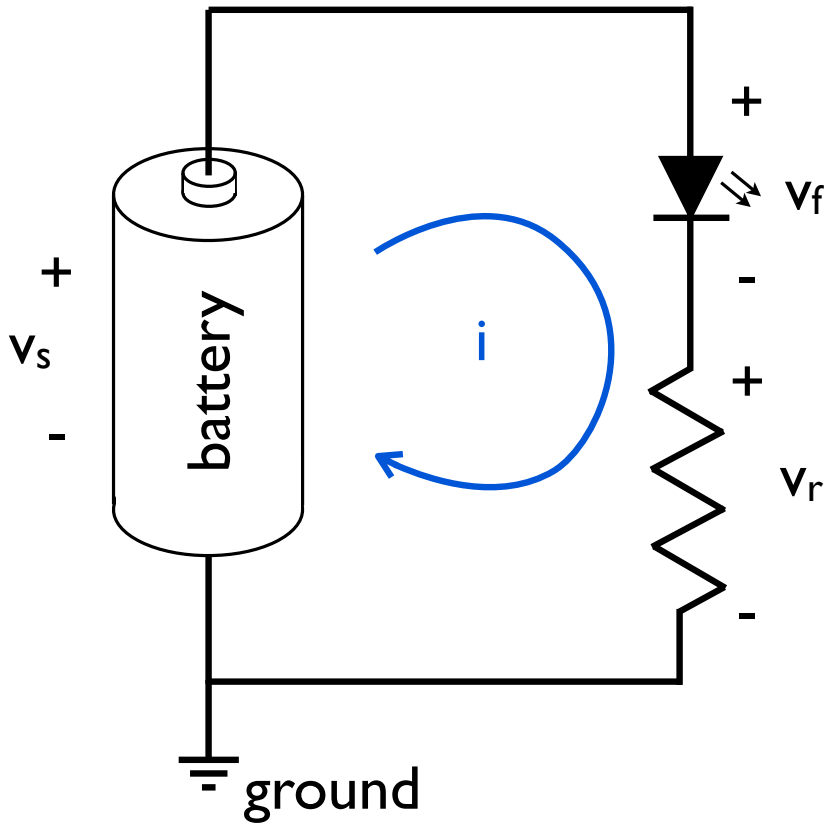


Every LED has a **forward voltage**, v_f, which defines how much voltage *drops* as the current passes through the LED

Also, an LED has a recommended **current rating**, which states how much current can safely go through the LED without burning it out

The higher the current, the brighter the LEDS shines.
But you **must limit this current**!

Light-emitting diodes (LEDs)

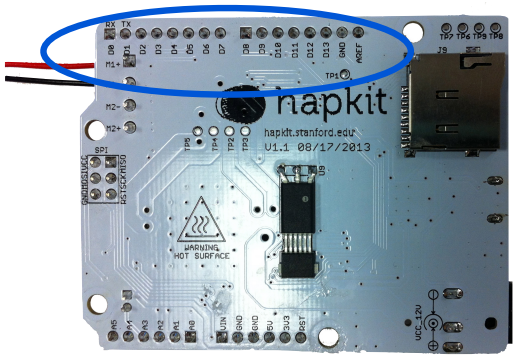


Problem:
Given a desired current **i** (due to LED current rating) supply voltage $\mathbf{v_s}$, and forward voltage of the LED $\mathbf{v_f}$, what size resistor should I use?

$$v_s = v_f + v_r$$

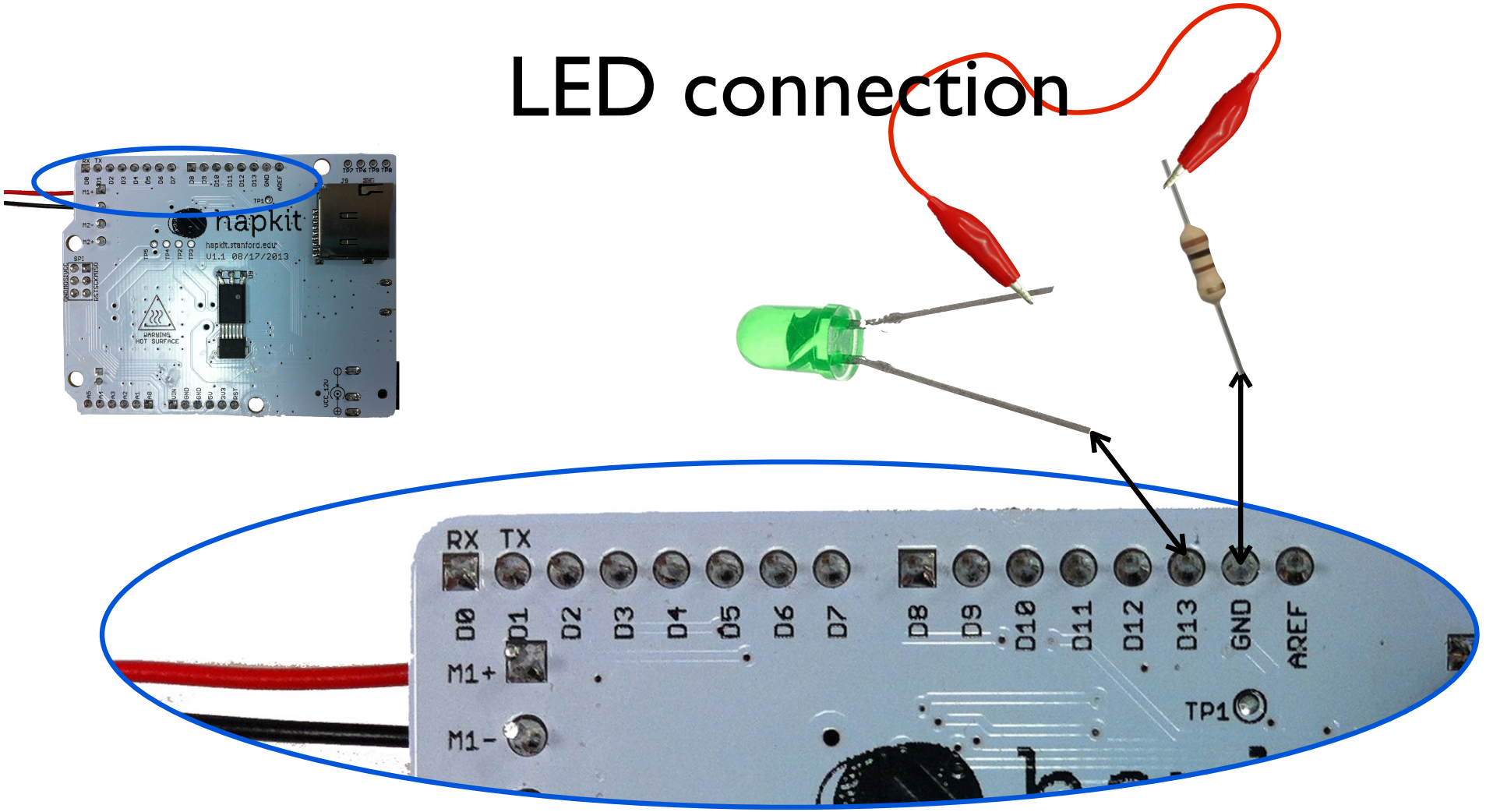
$$i = v_r / R$$

LED connection

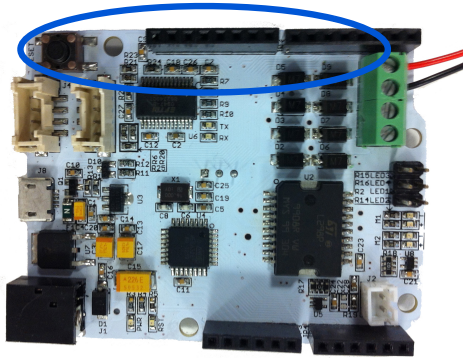


When commanded to go HIGH, pin 13 will output approximately 5 V

LED connection



LED connection



After you finish the next set of quiz questions, make this circuit on your Hapkit board

Programming Hapkit

Arduino is a single-board microcontroller that makes using electronics in multidisciplinary projects relatively easy

The Hapkit board is based on the Arduino design, with some added features

The Hapkit board can be programmed using the same Arduino integrated development environment (IDE) as an Arduino board

Follow the instructions in the handout to download, install, and test the Arduino software

Example Hapkit Program

Code:

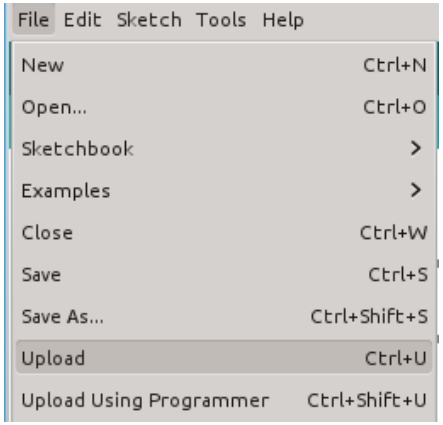
```
// Blink the pin 13 LED
void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);
  delay(1000);
  digitalWrite(13, LOW);
  delay(1000);
}
```

The Arduino programming language is similar to C and java

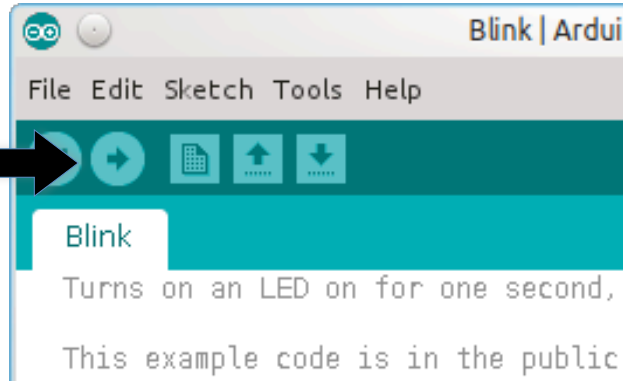
material courtesy Paulo Blikstein

Running a Hapkit Program



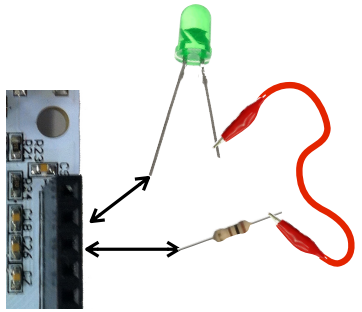
Click
File > Upload

or click the Upload button



Clicking Upload sends the code from the computer to the Hapkit board

Your code is now running on the Hapkit Board!
What is the LED doing?



material courtesy Paulo Blikstein

Understanding the code

```
// Blink the pin 13 LED
void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);
  delay(1000);
  digitalWrite(13, LOW);
  delay(1000);
}
```

void setup() { … }
Any code inside the setup function runs *once* to setup the Arduino

void loop() { … }
Any code inside the loop function loops over and over again

material courtesy Paulo Blikstein

Understanding the code

```
// Blink the pin 13 LED
void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);
  delay(1000);
  digitalWrite(13, LOW);
  delay(1000);
}
```

pinMode(Pin Number, INPUT or OUTPUT)

This tells the Arduino whether the pin is an input (ie. sensor, switch) or an output (ie. LED, motor). Pin 13 is connected to an LED on the board. The other pins can be externally connected to whatever you want!

material courtesy Paulo Blikstein

Understanding the code

```
// Blink the pin 13 LED
void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);
  delay(1000);
  digitalWrite(13, LOW);
  delay(1000);
}
```

digitalWrite(Pin Number, HIGH or LOW)

This makes the specified pin HIGH (a digital 1) or LOW (a digital 0). The LED is on if it is HIGH and off if it is LOW. We first make the LED turn on by making pin 13 HIGH, then we make it turn off by making pin 13 LOW.

Digital 0 = 0 Volts = LOW

Digital 1 = +5 Volts = HIGH

delay(Milliseconds)

This makes the Arduino wait for the specified number of milliseconds. Without the delay, the LED would blink so fast, you wouldn't notice!

material courtesy Paulo Blikstein

The Serial Monitor

- The Arduino environment's built-in serial monitor can be used to communicate with your Hapkit board
- In the menu, click on **Tools > Serial Monitor** to view
- You can use the following code to interact with the serial monitor:

to print to the serial monitor:

```
Serial.println("Hello World!");

int my_variable = 0; // variable
Serial.println(my_variable);
```

to read from the serial monitor:

```
if (Serial.available() > 0)
{
  char inByte = Serial.read();
}
```

Programming syntax/hints

- Use // before any text you want to have as a comment (and comment well!)
- Each statement must end with a ; (semicolon)
- You must declare variables before you use them
- Call built-in Arduino functions to perform I/O (input/output)
- See http://arduino.cc/en/Reference/HomePage for a language reference that describes structure, variables, and functions
- If you have never programmed before, the easiest way to learn is by looking at and modifying example programs. Don't modify too many things at once before testing your code. Many examples under File > Examples

TO DO

- Continue to bring your laptop and power cord to class
- If possible, finish constructing your Hapkit (with new laser-cut sector pulley) before class on Thursday. If you need help, we can finish in class after the lecture portion.
- Make yourself a shelf label for your Hapkit and accessories