



Tech Explorations

Arduino Step by Step

Getting Serious

List of parts

Parts needed for all lectures

- 2 x Arduino Uno (some demos require 2 Arduinos)
- Assorted male-male jumper wires
- Assorted through-hole resistors
- Several LEDs
- Breadboard friendly momentary buttons

Software needed for all lectures

- Arduino IDE

Tools needed for all lectures

- A digital multimeter
- A battery pack or bench power supply
- Antistatic tweezers
- Power supply capable of supplying 5V and 12V, at least 1A

#	Section	Lecture	Components
1	Introduction to this course	Introduction Study guide List of parts Should you buy all the parts featuring in this course? How to ask a question How to report an error Is this course right for you?	No parts needed
2	The BME280 environment sensor	Introduction to the BME280 BME280 SPI wiring BME280 I2C wiring BME280 Sketch walkthrough and demo	- BME280 environment sensor
3	The MPU6050 motion sensor	Introduction to the MPU6050 motion sensor A look at the MPU6050 datasheet MPU6050 wiring MPU6050 Arduino sketch MPU6050 Processing demonstration MPU6050 bonus lecture	- MPU6050 motion sensor
4	Compass and magnetometer	Introduction to the HMC5883 compass magnetometer HMC5883 wiring HMC5883 sketch HMC5883 demonstration	- HMC5883 compass

5	The flex sensor and membrane potentiometer	Introduction to the flex sensor	<ul style="list-style-type: none"> - Flex sensor, 2.2" (5.588cm) long - Spectrasymbol membrane potentiometer (SoftPot)
		Flex sensor wiring	
		Flex sensor sketch	
		Introduction to the membrane potentiometer	
		Membrane potentiometer demonstration	
6	The rotary encoder	Introduction to the rotary encoder	<ul style="list-style-type: none"> - Rotary encoder
		Rotary encoder wiring and quadrature encoding	
		Rotary encoder sketch	
7	Keypads	Introduction to the keypad	<ul style="list-style-type: none"> - 4x4 flexible keypad - Phone-style keypad - 3 x 4.7 kΩ resistors - 4 x 1 kΩ resistors - 2 x 0.1 μF capacitor - 1 x 1 μF capacitor - 1 x MM74C922 decoder IC
		Working out the keypad pins	
		Keypad wiring	
		The phone keypad	
		Keypad 1-wire connection, Introduction	
		Keypad 1-wire connection, wiring	
		Keypad 1-wire connection, sketch	
		Keypad with the 74922 decoder IC, Introduction	
		Keypad with the 74922 decoder IC, wiring	
		Keypad with the 74922 decoder IC, sketch and demo	
		Bitwise operators	
8	Graphics screen: Using a 1.8" TFT screen shield with joystick and SD card	Introduction	<ul style="list-style-type: none"> - Adafruit 1.8" TFT Color shield with micro SD and joystick - Micro SD card
		Setup, graphics primitives and documentation	
		Displaying images from the SD card	
		Using the joystick and integrated button	
		How to create your own user interface: make the background image	
		How to create your own user interface: an example sketch	
9	Graphics screen: Using a 2.2" TFT with SD Card	Introduction	<ul style="list-style-type: none"> - Adafruit 240x320 2.2" TFT screen with the ILI9340C controller
		Wiring	
		Simple demonstrations	
		Displaying data	
		The library and resources	
10	2.8 inch TFT display with touch interface and SD card module	Introduction	<ul style="list-style-type: none"> - 2.8" TFT screen - Micro-SD card
		Setup the IDE	
		Graphics functions and documentation	
		Test the touch interface	
		Test the SD card module	
		Create a custom user interface image	
		Create a custom user interface sketch	

11	Graphics screen: using the 128x64 OLED SPI SH1106 display	Introduction	- 128x64 OLED SPI display with the SH1106 controller
		Wiring	
		Libraries and support	
		Finding the right constructor for your screen	
		Demo sketch	
12	8x8 LED matrix display	Introduction	- 4 x 8x8 LED matrix displays using the MAX7219 controller
		Single display wiring	
		Single display sketch	
		Single display drawing	
		Custom graphics	
		Animation	
		Four 8x8 LED matrix display introduction	
		Four 8x8 LED matrix display graphics primitives	
13	Seven Segment Displays	Introduction	- Single seven segment display, common cathode - Dual seven segment display, common cathode - Seven segment clock display, common cathode - 0.56" 4-digit Seven segment clock display with I2C backpack - 74HC595 shift register IC - 8 x 330 Ω resistors
		Single display pin role discovery	
		Single display wiring	
		Single display sketch	
		Single display, working out the digit byte array	
		Single display with a single resistor	
		The sevseg library	
		Dual seven segment display, pin discovery	
		Dual seven segment display, wiring	
		Dual seven segment display, sketch	
		Single seven segment display with shift register, Introduction	
		Single seven segment display with shift register, wiring	
		Single seven segment display with shift register, sketch	
		Seven segment clock display - Introduction	
		Seven segment clock display - pin discovery	
		Seven segment clock display - wiring	
		Seven segment clock display - sketch	
		Seven segment clock display - Demo and wiring correction	
		Seven segment clock display with I2C backpack - Introduction and wiring	
		Seven segment clock display with I2C backpack - sketch	
		Seven segment clock display with I2C backpack - demo and wiring correction	
14	LED strips	White 12V LED strip with the TIP122 transistor, Introduction	- White 12V LED strip - RGB LED strip - 3 x TIP122 Darlington transistors - 12V power supply - 3 x 1 k Ω resistor
		White 12V LED strip with the TIP122 transistor, TIP122 datasheet	
		White 12V LED strip with the TIP122 transistor, circuit	
		White 12V LED strip with the TIP122 transistor, wiring test	
		White 12V LED strip with the TIP122 transistor, blinking	
		White 12V LED strip with the TIP122 transistor, fading	
		RGB LED strip with the TIP122, introduction	
		RGB LED strip with the TIP122, testing	
		RGB LED strip with the TIP122, circuit and wiring	
		RGB LED strip with the TIP122, sketch	
15	Neopixel LED modules	Adafruit Neopixel 5x8 shield, Introduction	- Adafruit Neopixel 5x8 shield - Adafruit Neopixel strip with 8 RGB LEDs
		Adafruit Neopixel 5x8 shield, Quick setup and demo	

		Adafruit Neopixel 5x8 shield, Sketch, control single pixels	- Adafruit Neopixel LED strip with 30 LEDs
		Adafruit Neopixel 5x8 shield, Sketch, draw graphic primitives	- 500 Ω resistor
		Adafruit Neopixel strip 8 LED, Introduction	- 1000 μ F capacitor
		Adafruit Neopixel strip 8 LED, Sketch introduction	- 5V power supply
		Adafruit Neopixel strip 8 LED, Circuit and assembly	
		Adafruit Neopixel strip 8 LED, Sketch walkthrough	
		Adafruit Neopixel RGBW 30 LED strip, introduction	
		Adafruit Neopixel RGBW 30 LED strip, Wiring	
		Adafruit Neopixel RGBW 30 LED strip, Programming and demo	
		Adafruit Neopixel RGBW 30 LED strip, Sketch walkthrough	
16	DC Motors	Introduction to motors	- 2 x 5V DC motors
		DC motors principles of operation	- L298N motor controller
		Motor control with the L298N, wiring	- L8871 motor controller
		Motor control with the L298N, sketch and demo	- Adafruit Motor Shield v2
		Motor control with the L8871, introduction	- 5V power supply
		Motor control with the L8871, Wiring	
		Motor control with the L8871, sketch and demo	
		Motor control with the Adafruit Motor Shield v2, introduction	
		Motor control with the Adafruit Motor Shield v2, Wiring	
		Motor control with the Adafruit Motor Shield v2, Sketch and demo	
17	Servo motors	Introduction to servo motors	- 2x Basic mini servo motor
		Direct control of a servo motor, wiring	- Continuous rotation servo motor
		Direct control of a servo motor, sketch and demo with one motor	- Adafruit Servo shield
		Direct control of a servo motor, sketch and demo with two motors	
		Define servo motor moves in an array	
		Continuous rotation servo motor	
		The Adafruit Servo Shield, introduction	
		The Adafruit Servo Shield, wiring	
		The Adafruit Servo Shield, Sketch	
		The Adafruit Servo Shield, Control an LED	
18	Stepper motors	Introduction to stepper motors	- NEMA17 stepper motor
		Dissecting a bipolar stepper motors	- L293 motor controller
		How to determine the coil wires of a bipolar stepper motor	- EasyDriver motor controller
		NEMA17 with the L293 controller and Stepper library, introduction and wiring	- Unipolar stepper motor
		NEMA17 with the L293 controller and Stepper library, sketch and demo	- Adafruit Motor Shield
		NEMA17 with the Easy Driver controller, introduction	- ULN2003 motor controller
		NEMA17 with the Easy Driver controller, wiring	- 12V power supply
		NEMA17 with the Easy Driver controller, sketch	- 5V power supply
		NEMA17 with the Easy Driver controller and AccelStepper, introduction and sketch	
		NEMA17 with the Easy Driver controller and AccelStepper, demo	
		NEMA17 with the Adafruit Motor Shield v2 and AccelStepper, introduction & sketch	
		NEMA17 with the Adafruit Motor Shield v2 and AccelStepper, Demo	
		Unipolar stepper motor with Adafruit Motor Shield, introduction	
		Unipolar stepper motor with Adafruit Motor Shield, determining coil wires	
		Unipolar stepper motor with Adafruit Motor Shield, demo	
		Unipolar stepper motor with the ULN2003 driver, introduction	
		Unipolar stepper motor with the ULN2003 driver, wiring	
		Unipolar stepper motor with the ULN2003 driver, sketch & demo	

19	Networking with the Ethernet Shield	Introduction to Ethernet networking	<ul style="list-style-type: none"> - Ethernet shield with the Wiznet 5100 controller - 10 kΩ photo resistor - 2 x 10 kΩ resistor - DHT22 sensor - LED - 330 Ω resistor
		The Ethernet shield	
		Simple chat server, introduction and wiring	
		Simple chat server, demonstration	
		Simple chat server, sketch	
		Simple chat server with LCD shield, wiring and demo	
		Simple chat server with LCD shield, sketch	
		Simple reporting web server, introduction and wiring	
		Simple reporting web server, sketch walkthrough part 1	
		Simple reporting web server, HTTP request formatting	
		Simple reporting web server, sketch walkthrough part 2	
		Simple reporting web server outputting CSV formatted data	
		Simple controlling web server with one LED, wiring and demo	
		Simple controlling web server with one LED, sketch	
		Simple controlling web server with two LEDs	
20	Networking with the ATWIN1500 Wifi module	Introduction to the ATWIN1500 Wifi module	<ul style="list-style-type: none"> - Adafruit ATWIN1500 Wifi module - An Amazon AWS account - DHT22 sensor - 10 kΩ photo resistor - 10 kΩ resistor - 2 x LED - 2 x 330 Ω resistors
		Wiring the Adafruit ATWIN1500 breakout	
		Adafruit ATWIN1500 Wifi breakout, simple demo	
		Adafruit ATWIN1500 Wifi breakout, sketch walkthrough	
		Adafruit ATWIN1500 Wifi breakout, firmware version check	
		ATWIN1500 Wifi breakout firmware upgrade	
		ATWIN1500 Wifi breakout SSL certificate update	
		ATWIN1500 Simple reporting server, wiring	
		ATWIN1500 Simple reporting server, sketch	
		ATWIN1500 Simple reporting server, demonstration	
		ATWIN1500 controlling LEDs with a CSV file on Amazon S3, introduction	
		ATWIN1500 controlling LEDs with a CSV file on Amazon S3, Setup the S2 service	
		ATWIN1500 controlling LEDs with a CSV file on Amazon S3, Demonstration	
		ATWIN1500 controlling LEDs with a CSV file on Amazon S3, sketch	
		ATWIN1500 controlling LEDs with a simple web server, introduction & demo	
		ATWIN1500 controlling LEDs with a simple web server, sketch	
21	Shift registers	Introduction to Shift Registers	<ul style="list-style-type: none"> - 2 x 74HC595 shift register ICs - 16 x 220 Ω resistors - 16 x LEDs - 470 μF capacitor
		Driving 8 LEDs with one 595 Shift Register, introduction and IC pin roles	
		Driving 8 LEDs with one 595 Shift Register, Assembly	
		Driving 8 LEDs with one 595 Shift Register, Sketch	
		Driving 16 LEDs with two 595 Shift Registers, introduction	
		Driving 16 LEDs with two 595 Shift Registers, wiring	
		Driving 16 LEDs with two 595 Shift Registers, sketch	
22	Simple Bluetooth connectivity with the HC-06	Introduction to the HC-06	<ul style="list-style-type: none"> - HC-06 Bluetooth module - 10 kΩ photo resistor - 10 kΩ resistor - LED - 330 Ω resistor
		HC-06 Wiring	
		HC-06 Pairing	
		HC-06 Reading sensor data	

		HC-06 with SoftwareSerial	
23	Bluetooth Low Energy (BLE) with the nRF8001	Introduction to BLE	- Adafruit BLE breakout with the nRF8001 module
		A few things about the BLE standard	- A smartphone
		nRF8001 setup	- RGB LED
		nRF8001 callBack Echo demo	- 5 x 330 Ω resistors
		nRF8001 simple duplex communications demo	- 2 x LEDs
			- 10 kΩ photo resistor
			- 10 kΩ resistor
24	Adafruit Bluefruit LE UART Friend	Introduction	- Adafruit Bluefruit LE UART Friend
		Pinouts	- A smartphone
		Wiring and Demo	- RGB LED
		Firmware update	- 5 x 330 Ω resistors
		AT Commands	- 2 x LEDs
		Serial data link demo	- 10 kΩ photo resistor
		Controlling data link demo	- 10 kΩ resistor
		HID Keyboard sketch	
		HID Keyboard demo	
		Controller demo	
25	Wireless connectivity with the nRF24	Introduction to the nRF24	- 2 x nRF24L01+ modules
		Module pinout	- 2 Arduino Unos
		Simple test wiring	- 2 x 470 μF capacitors
		Simple test sketch	- 2 x LED
		Simple test demo	- 2 x 330 Ω resistors
		Comprehensive demo	- 20 kΩ resistor
		Comprehensive demo sketch	- 10 kΩ photo resistor
			- 10 kΩ resistor
		- Breadboard friendly momentary button	
		- 2x16 character LCD screen with I2C backpack	
26	Simple radio communications at 433Mhz	Introduction	- 1 x 433Mhz receiver XY-MK-5V
		Receiver and transmitter pins and wiring	- 1 x 433Mhz transmitter XY-FST
		Receiver and transmitter sketches	- 2 x LED
		Demo	- 2 x 330 Ω resistor
28	External Storage	Reading and writing to an SD card, Part 1 of 3	- SD card module with SPI for Arduino
		Reading and writing to an SD card, Part 2 of 3	- A blank SD card formatted as FAT16
		Reading and writing to an SD card, Part 3 of 3	- External EEPROM module, 256 kB with the 24C256
		EEPROM (internal and external) Part 1: Basic use	- 2 x 10 kΩ photo resistor
		EEPROM (internal and external) Part 2: the EEPROMex library	- 10 kΩ resistor
		EEPROM (internal and external) Part 3: Using an external EEPROM	- Thermistor
29	Interrupts	Hardware interrupts Part 1: Introduction	- Arduino Uno
		Hardware interrupts Part 2: Using volatile variables	- LED
		Hardware interrupts Part 3: Timers	- 300 Ω resistor
		Hardware interrupts Part 4: High-definition Pulse Width Modulation	- 10 kΩ resistor
			- Breadboard-friendly momentary button
30	Memory and power management	Memory management Part 1: Introduction and Flash	- Arduino Uno
		Memory Management Part 2: Static RAM	

		Power management with sleep mode and prescaling	
31	Internal pull-up resistors	Using the build-in pull-up resistors	<ul style="list-style-type: none"> - Arduino Uno - LED - 330 Ω resistor - 10 kΩ resistor - Breadboard-friendly momentary button
32	Hardware debouncing	Hardware switch/button debouncing Part 1: Background	<ul style="list-style-type: none"> - 1 x 74HC14 Schmitt trigger IC
		Hardware switch/button debouncing Part 2: Demo	<ul style="list-style-type: none"> - 100 nF capacitor - 20 μF capacitor (optional) - 100 Ω resistor - 2 x 10 kΩ resistor
33	Port expander	Control more devices with a port expander, Part 1: Background and setup	<ul style="list-style-type: none"> - 1 x MCP23017 Port expander - 4 x 10 kΩ resistors - 2 x LED
		Control more devices with a port expander, Part 2: more examples	<ul style="list-style-type: none"> - 2 x 330 Ω resistors - Breadboard-friendly momentary button
34	Real time clock	Real time clock, Part 1 of 2	<ul style="list-style-type: none"> - RTC module TinyRTC v1.1 - SD card module - Photoresistor - Thermistor
		Real time clock, Part 2 of 2	<ul style="list-style-type: none"> - 2 x 10 kΩ resistors
35	Controlling large loads with relays and friends	Using the TIP22 transistor to control an LED strip	<ul style="list-style-type: none"> - TIP122 Darlington transistor - 12V power supply - 12V LED strip
		Relays Part 1: Introduction	<ul style="list-style-type: none"> - 5V relay
		Relays Part 2: How NOT to control a relay	<ul style="list-style-type: none"> - 2N2222 transistor
		Relays Part 3: Connect a 12V relay component calculations	<ul style="list-style-type: none"> - 1 kΩ resistor
		Relays Part 4: Connect a 12V relay connections	
		Relays Part 5: Relay shields	
36	Location sensing	Introduction to GPS	<ul style="list-style-type: none"> - Adafruit Ultimate GPS breakout
		Wiring the Adafruit module for direct communication with computer	
		Getting and using raw text data from the module	
		Using the Adafruit GPS library	
		Using the TinyGPS+ library	
37	Make a bare-bones Arduino	Intro and power circuit	<ul style="list-style-type: none"> - Atmega 328P - 16MHz crystal oscillator
		Atmega, reset and clock	<ul style="list-style-type: none"> - 2 x 22 pF capacitors
		Power LED and testing	<ul style="list-style-type: none"> - 2 x 10 μF capacitors
		Create your own printed circuit boards (PCB), Part 1	<ul style="list-style-type: none"> - 7805 Voltage regulator - 2 x LEDs
			<ul style="list-style-type: none"> - 2 x 330Ω resistors - Breadboard-friendly momentary button
		Create your own printed circuit boards (PCB), Part 2	<ul style="list-style-type: none"> - Fritzing PCB design software (free)
38	How to use Processing (language) with the Arduino	Using Processing (the language) with the Arduino, Part 1	<ul style="list-style-type: none"> - DHT22 sensor - 2 x 10 kΩ resistors - 220 Ω resistor - 10 kΩ potentiometer
		Using Processing (the language) with the Arduino, Part 2	<ul style="list-style-type: none"> - LED

39	Make your own simple library	Create your own Library, Part 1	No parts needed
		Create your own Library, Part 2	
40	Simple security with a fingerprint scanner	Introduction to the fingerprint scanner	<ul style="list-style-type: none"> - Fingerprint sensor - Electromagnetic lock - TIP122 - 12V power supply
		Wiring, registering and recognizing fingerprints	
		Sketch and demonstration with an electric lock	
41	Small projects	Arduino-Raspberry Pi wireless communication with the RF24	<ul style="list-style-type: none"> - Any version of the Raspberry Pi - Arduino Uno - 2 x nRF24L01+ module
		A home notification board with a large display	
		Using a magnetometer to detect motion	
			<ul style="list-style-type: none"> - 16x32 LED matrix display - Piezo buzzer - RTC breakout - DHT22 sensor - Arduino Ethernet shield
			<ul style="list-style-type: none"> - 3-axis HMC5883L magnetometer