

Electricity, Electronics, and Automation

Name: Emily Watson

Grades: 6 - 12

Time in Class: Sixteen (16) 1 hour and 30-minute classes. Each class will consist of ~30 minutes of class instruction and ~1 hour of laboratory work depending on the material. The final 10 minutes will be for review and storing laboratory equipment.

PREREQUISITES: Mathematics – students will be expected to be able to do decimal fraction calculations with a calculator

COURSE OBJECTIVES

- 1) For students to learn the basic physics of electricity
- 2) For students to learn how electron flow is used to power devices
- 3) For students to learn how to operate basic electronic equipment like digital multimeters and power supplies
- 4) For students to become familiar with the operation of basic electronic components: resistors, capacitors, diodes, LEDs, transistors, digital logic
- 5) For students to learn how electronic components interface with electromechanical devices
- 6) For students to learn programming basics as it relates to microcontrollers
- 7) For students to learn how to interface microcontrollers with electromechanical devices
- 8) Prepare students for advanced courses in Automation and Robotics

LIST OF MATERIALS (for a class of 30 students):

- 1) Classroom AV media devices
- 2) 20 Balloons
- 3) 60 AA Batteries
- 4) 60 3v Light Bulbs
- 5) 500 Assorted Resistors
- 6) 100 Assorted 1 W Zener Diodes
- 7) 30 50V 1 Amp Diodes
- 8) 2 20 Drawer Organizer
- 9) 400 Assorted TTL SSI Chips
- 10) 100 5 Amp Full Wave Bridges
- 11) 100 1000 uF 35V Capacitors
- 12) 30 7805 Regulators
- 13) 30 7812 Regulators
- 14) 5 Heat Sinks w/Hardware
- 15) 30 Temperature/Humidity Sensors
- 16) 30 Infrared Sensors
- 17) 20 Voltmeters
- 18) 25 Arduino Unos
- 19) 20 Breadboards

- 20) 300 M2M Jumpers
- 21) 100 M2F Jumpers
- 22) 50 2N2222 Transistors
- 23) 50 Red LEDs
- 24) 50 Green LEDs
- 25) 20 16-1 Port Extenders
- 26) 20 Battery Holders
- 27) 20 Small Motors
- 28) 20 Arduino Starter Kits
- 29) 20 Stepper Motors
- 30) 20 Servo Motors

CLASS DESCRIPTION (each class period):

- **Engage** (30 minutes – 1 hour depending on material covered): Using various media, explain the physics of the concepts being presented or the operations of the device under study. Use multimedia (charts and video) to enhance topic. Explain to the students the goals of the labs and demonstrate the lab procedures.
- **Laboratory / Explore** (30 minutes - 1 hour depending on material covered): Students will receive a lab sheet describing the procedure to follow and the data needed from the lab. Teacher and assistant will give individual instructions for students needing assistance.
- **Review** (10 minutes): The teacher will review the results from various teams to include what parts of the laboratory were successful and which parts were not.

Week 1 - Electricity Basics – Electrons, Conductors, and Insulators

Resources: [“Electricity - HOW WOULD YOUR LIFE BE DIFFERENT WITH NO ELECTRICITY?”](#)

Topics: The Atom, electrons, metals, plastics

Laboratory:

- 1) Wire Types to Examine and Describe
- 2) Static Electricity – Attraction and Repulsion

Laboratory Materials: Wires samples, Balloons to create static electricity, Paper shreds to show attraction

Week 2 - Digital Multimeter – Voltage, Resistance, and Current in A Basic Circuit

Resources: “STEM Teacher Activity – The Digital Multimeter: Something for Everyone”

Topics - Safety – Probes: Resistance in a circuit; resistor codes

Laboratory: Voltage and Resistance Measurements; Current Measurements

Week 3 - Electric Flow – Batteries and Circuits

Resources: [“How Circuit Breakers Work”](#)

Topics: Direct Current; Voltage and Current; Battery Circuits

- Alternating Current – Your Electric Life; Generators and Power Plants; Transmission
- SAFETY DEMONSTRATION – Transformers, Short Circuits, and Circuit Breakers

Laboratory: Battery Circuits, Loads

Week 4 - Series and Parallel Circuits

Resources: ["Circuits"](#)

Topics: What is a series circuit? What is a parallel circuit?

After Lab:

- The TWO LAWS of circuits
- OHM's LAW, Wheatstone Bridge

Laboratory: Series Circuit, Parallel Circuit

Week 5 - Your First Electronic Component – The Diode

Resources: ["How Semiconductors Work"](#)

Topics: Diode Physics; Diode specifications; Look for the Band; Zener Diodes

Laboratory: Diode Circuit; Zener Circuits

Week 6 – That Special Diode – The LED

Resources: ["How Light Emitting Diodes \(LEDs\) Work"](#)

Topics: How does a lightbulb work? How does a Light Emitting Diode work?
Voltage drop; Need for resistance

Laboratory:

- Lightbulb versus LED efficiency; LED specifications
- SAFETY DEMONSTRATION – Break an LED

Week 7 - The Transistor

Resources:

- ["How Transistors Work"](#)
- ["The Most Important Invention of the 20th Century: Transistors"](#)

Topics: How does a Transistor Work?; Current Amplification; Switching

Laboratory: Transistor Switching Circuit with LEDs

Week 8 - Power for your projects

Resources:

["How Electronic Gates Work"](#)

["How PC Power Supplies Work"](#)

Topics: Voltage Regulation – Resistance, Zener, Active; AC to DC – Full Wave Bridge; Capacitors; 78XX Regulators

Laboratory: AC to DC Conversion – Pulsed, Smoothing, Ripple; Regulator Circuits; HEAT SINKS; Power supplies

Week 9 - Transistor-Transistor Logic (TTL) – Your First Digital Integrated Circuits

Resources:

["What's the Difference Between Analog and Digital Technology?"](#)

["How Electronic Gates Work"](#)

Topics: Analog versus Digital; Boolean Logic – OR, AND, NOR, NAND, XOR; Truth Tables; TTL Chips; TTL families; SSI, MSI, LSI

<p>Laboratory: Chip identifications and Specifications; Simple Logic Circuits</p>
<p>Week 10 – Timers and Flip-Flops Topics: Clocks and Pulses; Frequency, Duty Cycle; Feedback Circuits, S-R Flip Flop, J-K Flip Flop Laboratory: 555 Timer; J-K Flip Flop, Binary Counter</p>
<p>Week 11- Switches and Sensors Resources: "What Is a Sensor?" "How Circuits Work" "Human and Robot Sensors" "What Is an IR Sensor?" Topics: DMM Continuity Function; Simple Switches; Compound Switches; Transducers; Sensors Laboratory: Switches and Logic; Momentary and Toggle Switches; Double Pole Switches; Double Pole Switches; IR Sensors</p>
<p>Week 12 - Logic Control of Devices I Resources: "TTL Data Book" by Texas Instruments "How Electronic Gates Work" Topics: TTL Specifications; Input and Output Specifications; Switching a Load; Switching a Relay Laboratory: TTL Inputs and Outputs; Driving a motor; Driving a Relay</p>
<p>Week 13 - Logic Control of Devices II Resources: "How Microcontrollers Work" "Tutorial Series for Arduino" by Jeremy Blum Topics: The Arduino UNO; Functions; First Program Laboratory Demonstration: The Programming Environment</p>
<p>Week 14 - Arduino Programming Resources: "Exploring Arduino: Tools and Techniques for Engineering Wizardry 1st Edition" by Jeremy Blum Topics: Variables; Math; Digital Input and Output; Analog Input Laboratory: Programming Blink; Count; Breath</p>
<p>Week 15 – Arduino Programming / Arduino Control of Devices I (Lesson Cont.) Topics: On/Off Motor Control</p>
<p>Week 16 – Arduino Control of Devices II Resources: "Tutorial 05 for Arduino: Motors and Transistors" Topics: Analog Motor Control with PWM; Servos; Triacs and AC</p>
<p>Extra Material - Arduino I2C Bus</p>

Resources: [“Tutorial 07 for Arduino: I2C Communication and Processing”](#)

Topics: What is a Bus?; I2C Specifications; I2C Device Programming