

Physics Experiments for an Introductory Electronics Course

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Goals

1. Provide interesting and rewarding ways to introduce students to electronics
2. Review and reinforce material studied throughout the semester
3. Demonstrate that even an introductory-level understanding of electronics is useful in the physics laboratory
4. Create experiments suitable for a Physics exploration center or outreach project

Mechanics

g by Free Fall

Phototransistor
Oscilloscope or Arduino* Digital Pin 2

+5 V
10 kΩ

+5 V
180 Ω
IR LED

Electromagnet*
Picket Fence
IR LED
Phototransistor

Log t for each pulse
Graph $x(t)$ to find g

g by Pendulum

Oscilloscope CH1 or Arduino Analog Pin

+5 V
 R_{pot}
GND

Measure period and compute g

g by Image Tracking

CMUcam5 Pixy Video Camera (50 Hz sample rate)

Microcontroller

Train Pixy to track green ball
Record $s(t)$ as ball rolls down ramp

Light

Planck's Constant

DMM

V_{out}

5 V fixed
0 - 5 V, 20 mA
 V_{in}

Digital DC Power Supply

$V_0 \approx \left(\frac{hc}{e}\right) \frac{1}{\lambda}$

Onset of LED emission at $V_{in} = V_0$
Measure V_0 for IR, red, yellow, green, violet

Phosphorescence Lifetime

UV LED
Phototransistor
Glow-In-Dark Plastic

Arduino Analog Pin
 V_{out}
GND

SparkFun Ambient Light Sensor
+5 V
UCC
Arduino Digital Pin

Arduino turns LED off and records $V_{out}(t)$
Don't forget to run a blank sample
Try different sample temperatures

Heat

Temperature Measurement

Adafruit MAX31855 thermocouple amplifier

Connect to Arduino and K thermocouple

Thermal Conduction

Fill containers with hot water
Record temps at equal t intervals

Thermal Radiation

Cover t-couples with colored paper
Record temps at equal t intervals

Sound

Tuning Fork

Oscilloscope CH1
GND
+5 V

SparkFun Electret Microphone

Connect sensor to oscilloscope
Measure pitch waveform and frequency

Speed of Sound in Air

Bubble Wrap
1 m

Mic 1
Oscilloscope CH1 or Arduino Digital Pin 2
GND
+5 V

Mic 2
Oscilloscope CH2 or Arduino Digital Pin 3
GND
+5 V

Pop bubble wrap
Measure delay between pulse arrival times

Speed of Sound in Al Rod

Piezo pickup

Double-Sided Tape

Oscilloscope CH2 or Arduino Digital Pin 3

Oscilloscope CH1 or Arduino Digital Pin 2

Strike end of bar with hammer
Measure pulse delay at piezo pickup

Wavelength of Sound

Function Generator 1 kΩ or Arduino Digital Pin

Speaker

Open End

Fixed End

Displacement Nodes

Oscilloscope CH1 or Arduino Analog Pin

SparkFun Electret Microphone

Generate audible tone from speaker
Measure distance piston moves between volume maxima (resonance)

Electricity

AC Mains

Oscilloscope CH1

Step-Down Transformer

Connect step-down transformer to oscilloscope
Measure AC waveform and frequency

Capacitor Charging Curve

Close at $t = 0$

Oscilloscope CH2

Oscilloscope CH1

Trigger scope off CH1, Record $V_C(t)$ on CH2
Measure $\tau = RC$ using oscilloscope cursors

AC Lighting

Oscilloscope CH1
GND
+5 V

SparkFun Ambient Light Sensor TEMT6000

Connect sensor to oscilloscope
Measure AC lighting waveform and frequency

Lenz's Law

Open switch at $t = 0$

$+10 V_0$

$L = 2.8 H$

Open switch with/without diode
Look for spark at switch

Miscellaneous

ECG Measurement

Sparkfun ECG Sensors

Attach sensors to subject and oscilloscope
Record ECG and identify origins of signal

Time between Random Events

GM Tube

Noise Generator

Log t for each random event
Generate histogram of Δt 's

FFT Spectral Wrapping

Oscilloscope Display Window

Set oscilloscope FFT sample rate to 12.5 kS/s
Set function generator to 1 kHz sine wave
Increase frequency in 1 kHz steps from 1-17 kHz
Mark spectral peaks
(Real: green, + Aliases: red, - Aliases: black)

0 1 2 3 4 5 6 6.25 kHz