OAQPS Teacher Workshop, July 8th

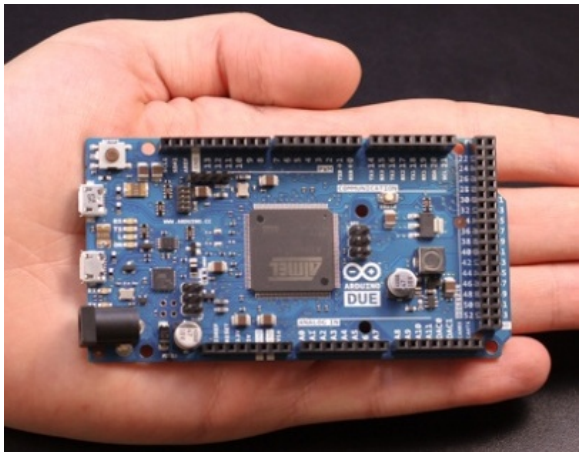
Village Green Project and Air Sensor Kits

Gayle Hagler

U.S. EPA Office of Research and Development

The emerging world of low cost sensors and electronics – an opportunity for STEM outreach and air science

A growing world of electronics supporting creative projects:



Arduino microprocessor – a simple computer

Lilypad Arduino – electronics meets home ec!

Image: http://web.media.mit.edu/

The emerging world of low cost sensors and electronics – an opportunity for STEM outreach and air science

Example air sensor components:

Nitrogen dioxide sensor
(Images courtesy of Ron Williams)

Carbon dioxide sensor

Particle sensor

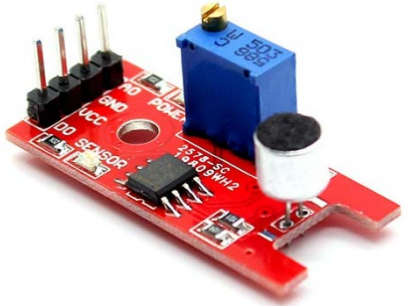
Particle sensor

- Some are “raw” components that need additional electronics work (an opportunity to build and learn!)
- Some are ready to turn on and collect data (an opportunity to measure!)
- All are portable, data quality is variable

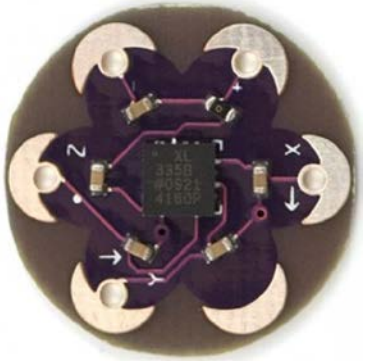
The emerging world of low cost sensors and electronics – an opportunity for STEM outreach and air science

Other sensors beyond air:

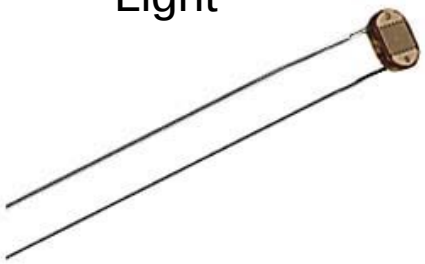
Noise



Motion (accelerometer)



Light



Relative Humidity

Temperature

Design of an air sampler: the basics

Learning how an air sampler is designed: the basic elements

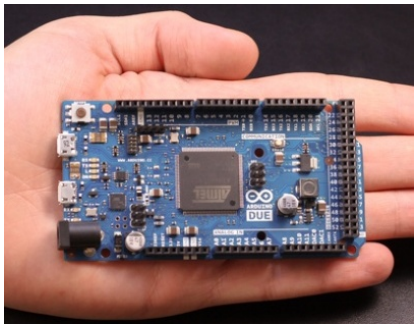
Design of an air sampler: the basics

Many examples emerging:

Air sensor → Computer ("data in, display out") → Data display

Carbon dioxide-sensing flower demo

CO_2 sensor



Arduino board

Light-up flowers displaying color based on concentration

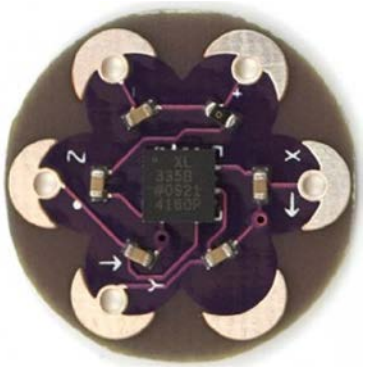
Design of an air sampler: the basics

Many examples emerging:

Air sensor → Computer ("data in, display out") → Data display

Wearable particle sensor

Particle sensor



Lilypad board

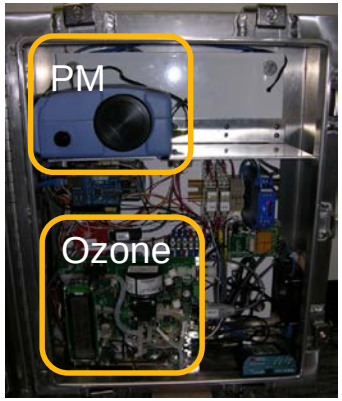
Wearable sensor with light indicator of concentrations

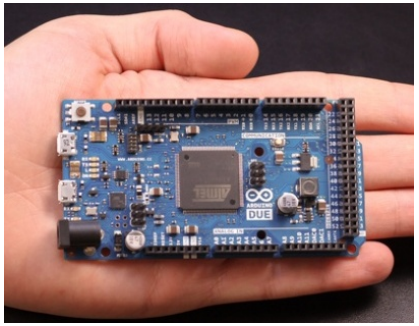
Winner of DHHS/EPA's My Health/My Air contest: David Kuller, Gabrielle Dockterman, and Dot Kelly

A slightly more complicated example!

Air sensor → Computer ("data in, display out") → Data display

Village Green Project





villagegreen.epa.gov

The Village Green Project

Solar-powered, air and meteorology monitoring bench:

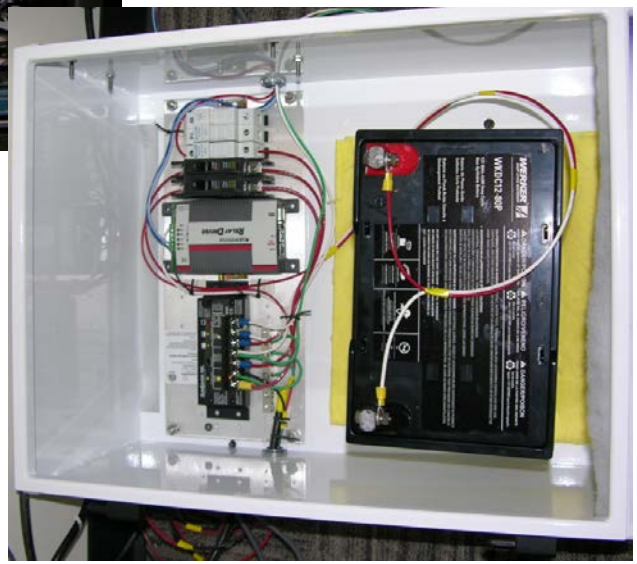
- Sustainable materials: manufactured from recycled milk jugs

- Tamper-proof: Instruments secured in bench or base of play structure

- Designed to add value to public environments

- Formal agreement with Durham County on collaboration

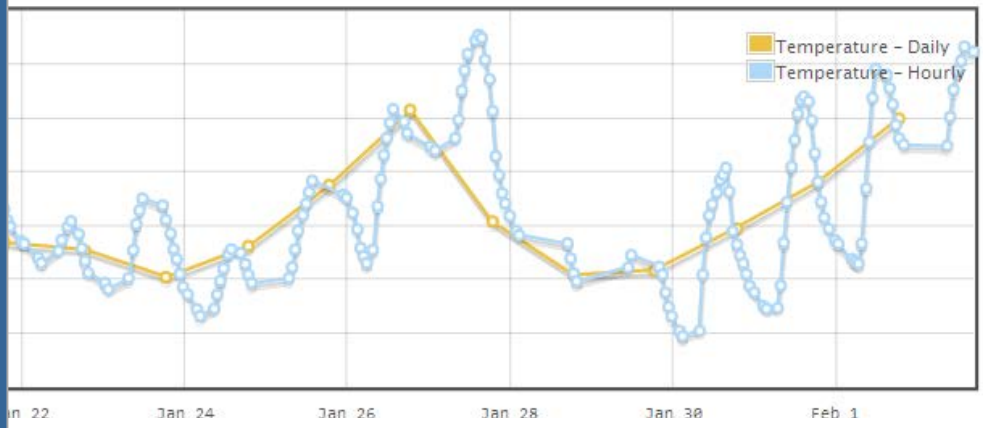
The Village Green Project

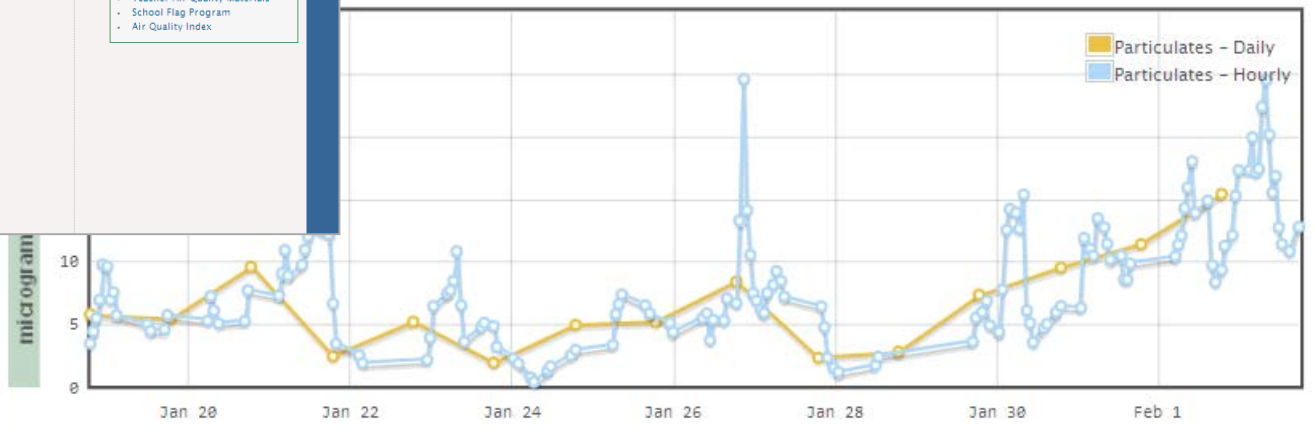


Air instruments (PM, ozone), power system and communications components stored securely behind bench

The Village Green Project

Public website updated minute-by-minute
http://villagegreen.epa.gov





Air sensor kit for outreach

Same general design strategy:

Goals:

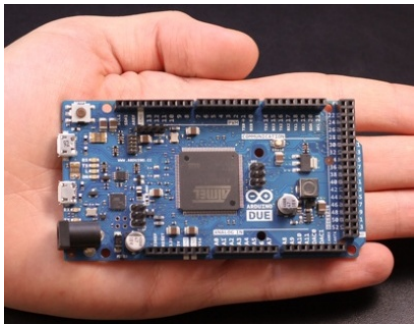
1. Hands-on learning about multiple STEM topics: air measurement science, electronics, computer programming.

2. Real-time and interactive data collection on an air pollutant of interest.

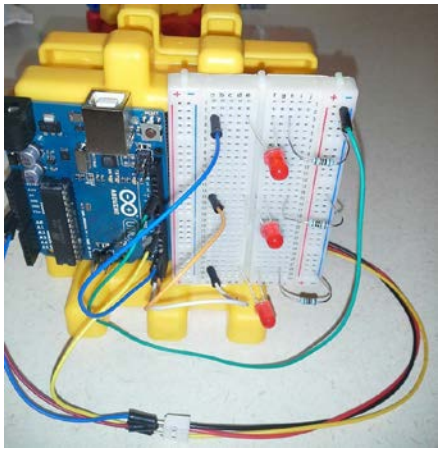
3. A fun, memorable experience that fits within a classroom hour!

Air sensor kit for outreach

Air sensor → Computer ("data in, display out") → Data display



Arduino board



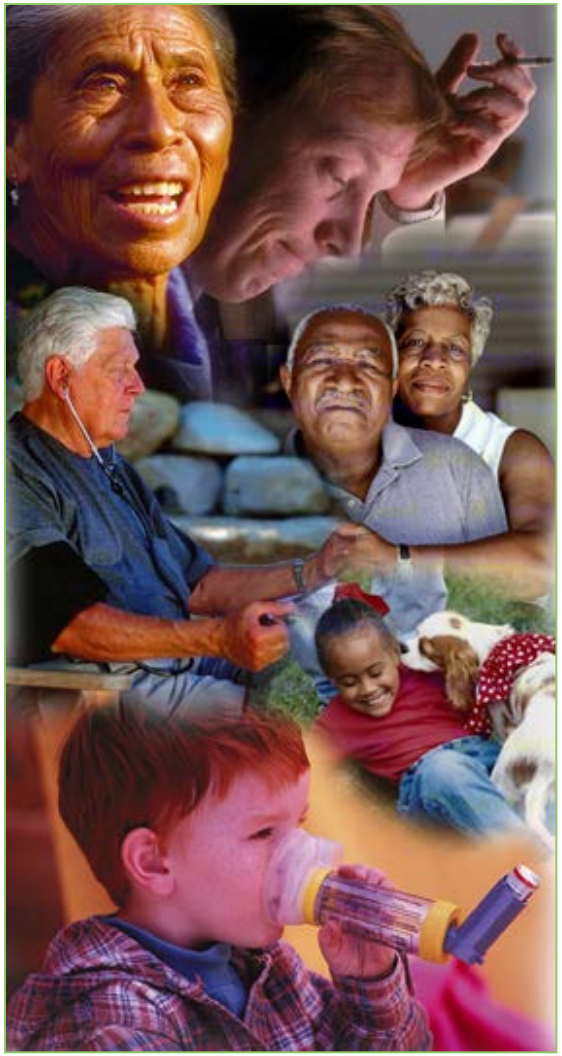
Portable "particle monitor" with LEDs lighting up to indicate concentration

Additional components:
- Resistors and wires
- Small battery
- 3 LEDs

Total kit cost:
~$65

Reuseable!

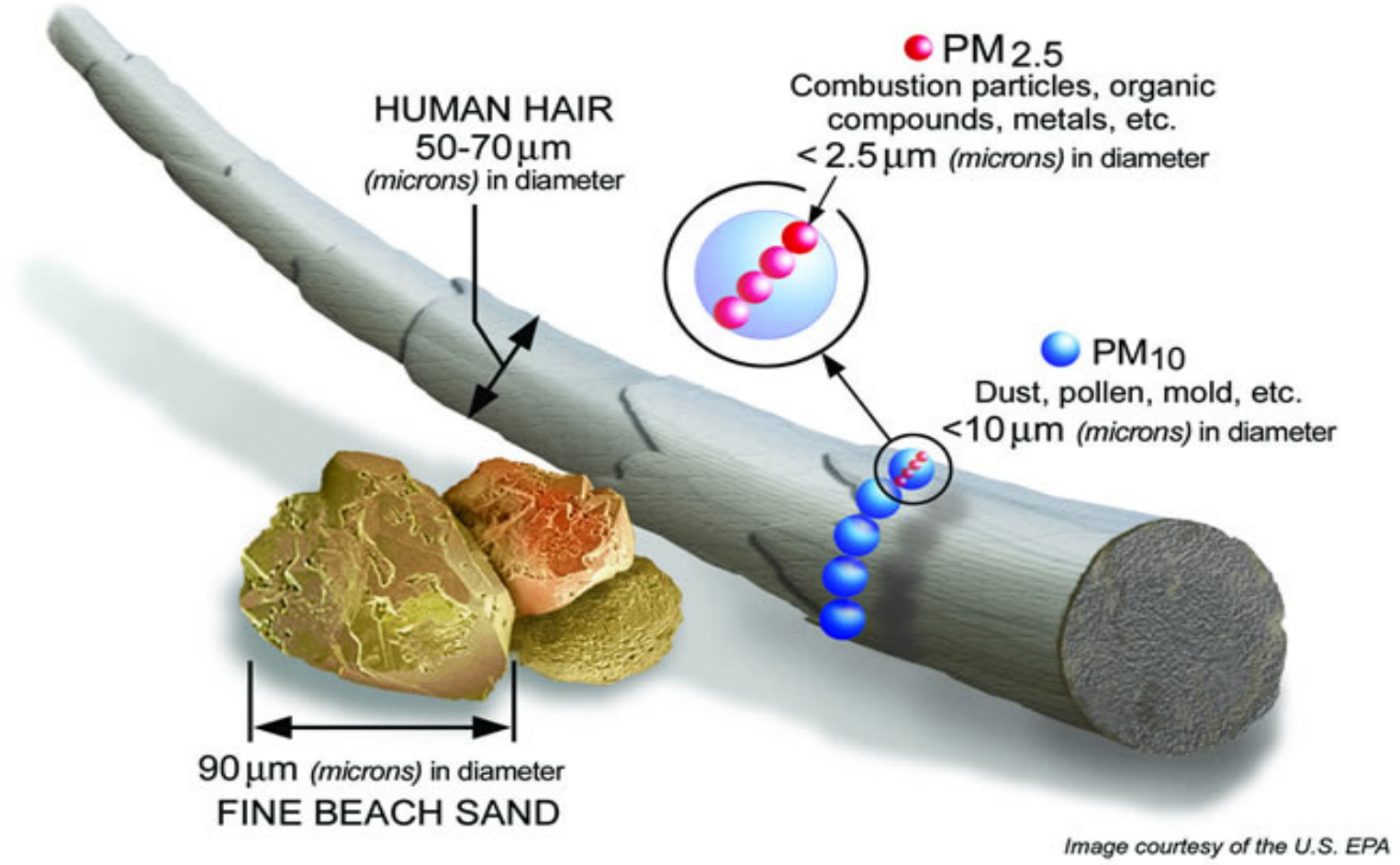
1. Give the big picture: EPA's goal for clean air



"The air in every American community will be safe and healthy to breathe. In particular, children, the elderly, and people with respiratory ailments will be protected from health risks of breathing polluted air."

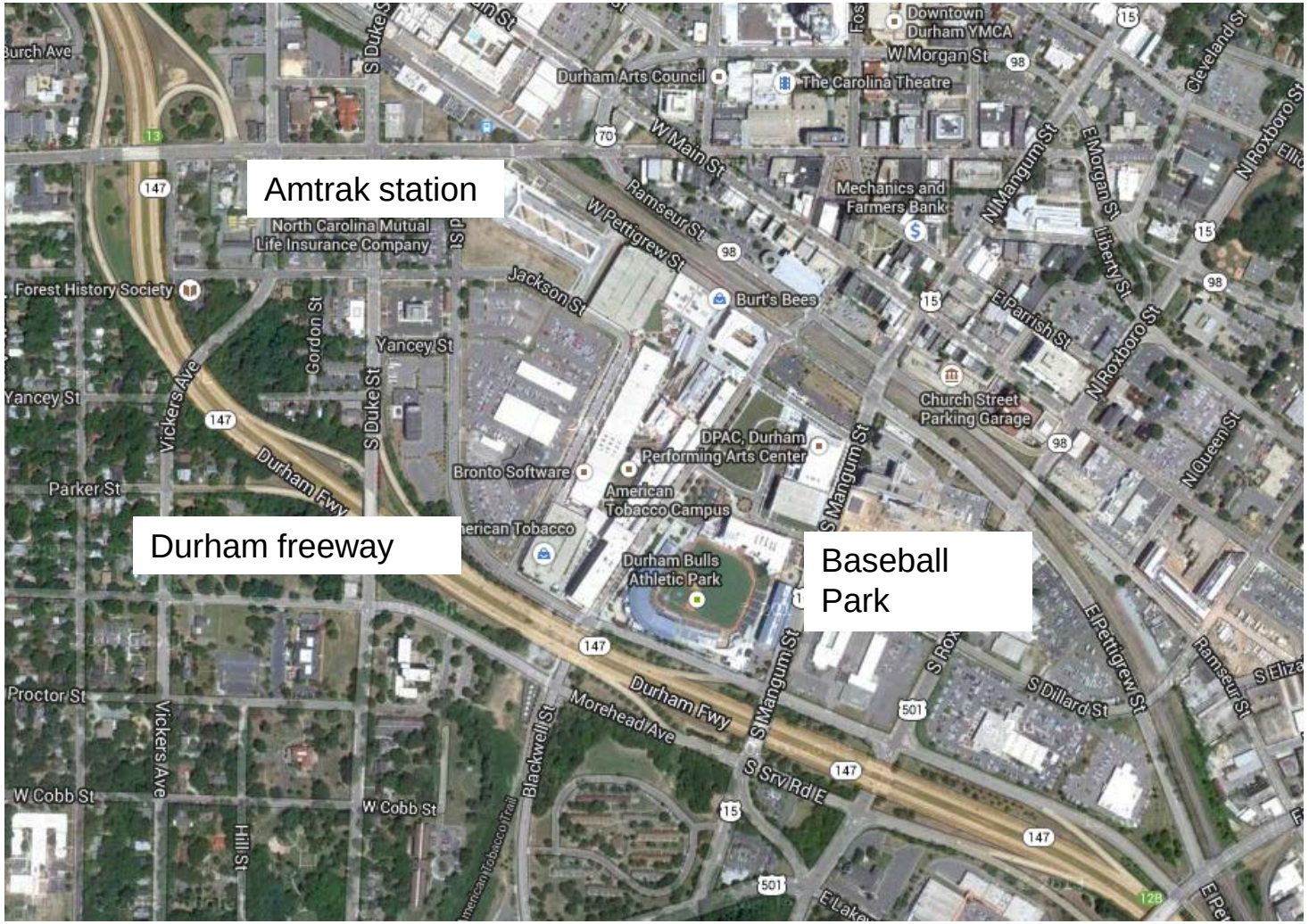
1. Give the big picture: What is Particulate Matter?

Introduction to the basics of air quality, particulate matter, and health



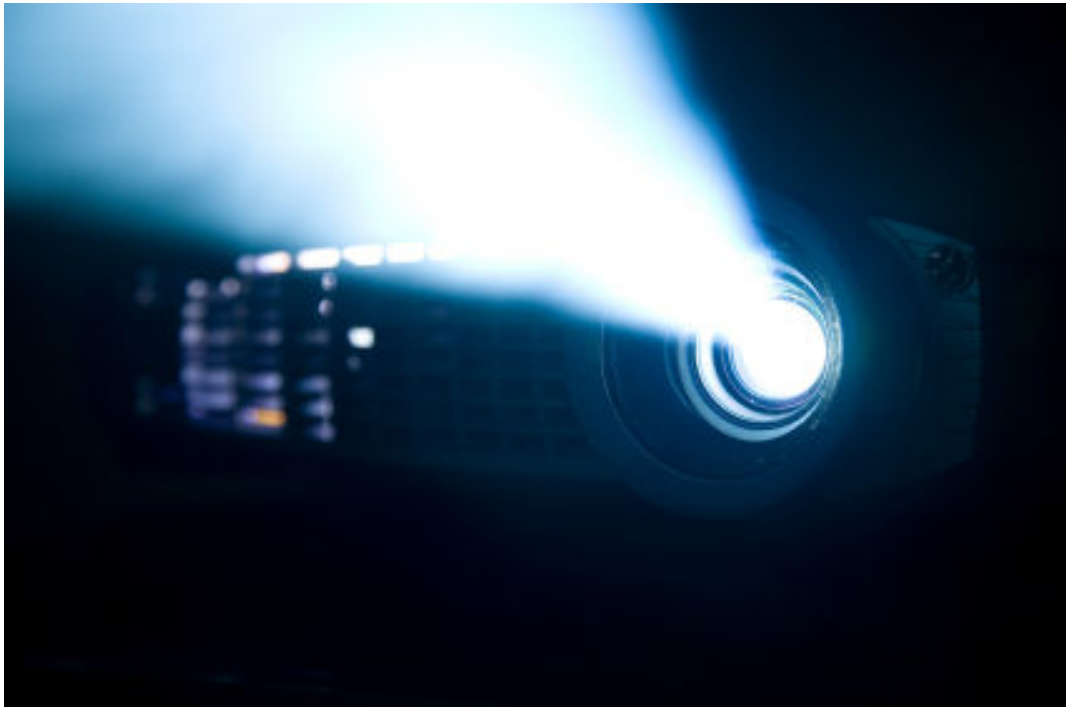
1. Give the big picture: How do scientists measure the air?

1. Give the big picture: Where would you choose to measure?



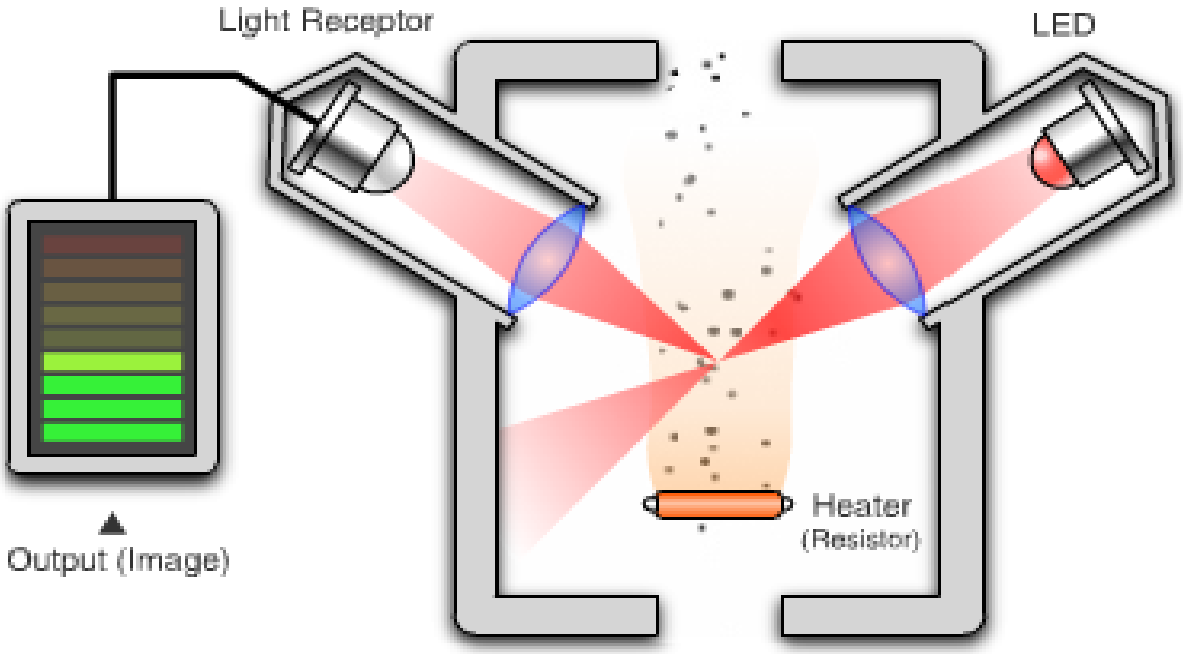
2. Primer on measuring particles

Introduction to measuring particles



The particle sensor works by measuring the light scattered by particles…have you ever seen something like this at the movies?

2. Primer on measuring particles



Works best oriented up (“hot air rises”)

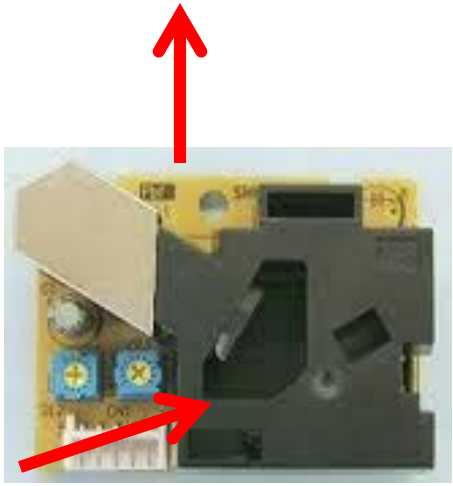


Image:

Air intake small white heater resistor visible in this opening

Credit: www.shinyei.co.jp

3. Explanation of the Arduino code

"These are the important pins! One will receive the PM signal, three will control the lights"

"Check the PM signal every 5 seconds"

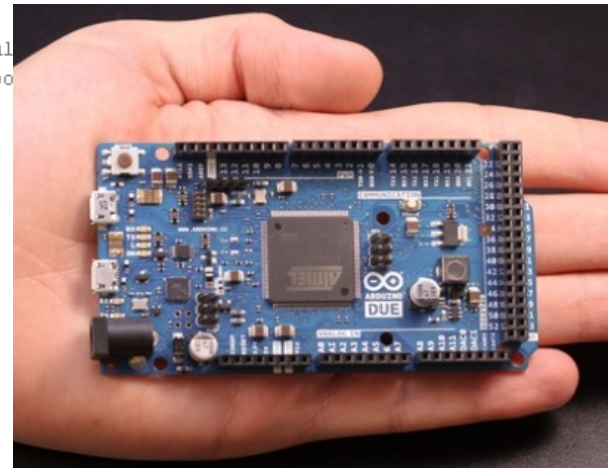
"Turn these lights on if PM level = …"

PM_outreach_best | Arduino 1.0.3

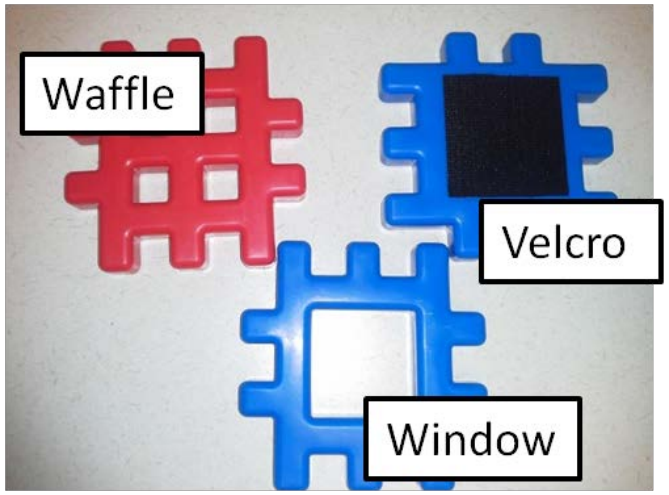
File Edit Sketch Tools Help

PM_outreach_best §

```
/*Build your own PM sensor Outreach activity
 grey text preceded by // or surounded by /* is commented code that is not read by the Arduino*/
int PM=8;//tell the arduino which pin you are plugging the PM sensor into
//tell the arduino which pin you are pluggin the LEDs into
int LED1=3;
int LED2=4;
int LED3=5;//could easily modify to use more LEDs
//Amount of time the sensor collects data before displaying the resul
//For PM sensor accuracy should be 30 s or greater (accuracy not impo
unsigned long sampletime_ms = 5000;
//Define additional Variables
unsigned long duration;
unsigned long starttime;
unsigned long lowpulseoccupancy = 0;
unsigned long timediff;
float ratio = 0;
void setup(){
  Serial.begin(9600);//start communication with computer
  //(not necessary just for error checking or code modification)
  pinMode(LED1,OUTPUT);//Define the LEDs as outputs
  pinMode(LED2,OUTPUT);
  pinMode(LED3,OUTPUT);
  pinMode(8,INPUT);
  starttime = millis(); //set the start time of the PM measurement
  //(millis() gives the time since the program started)
  Serial.println("BUILD YOUR OWN SENSOR INITICIALIZING");//Prints to the computer screen
}
void loop (){
```

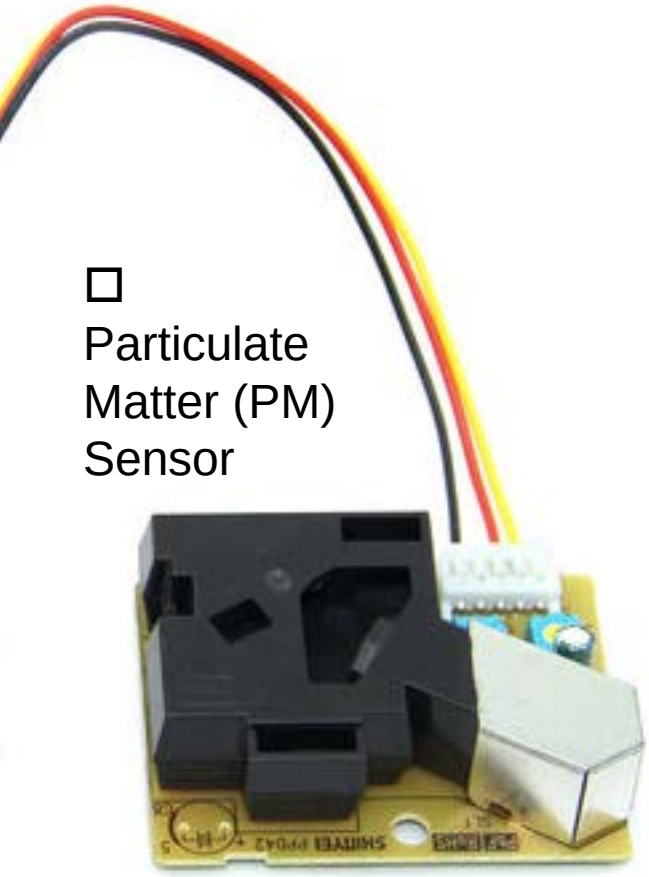


4. Explain all the kit components

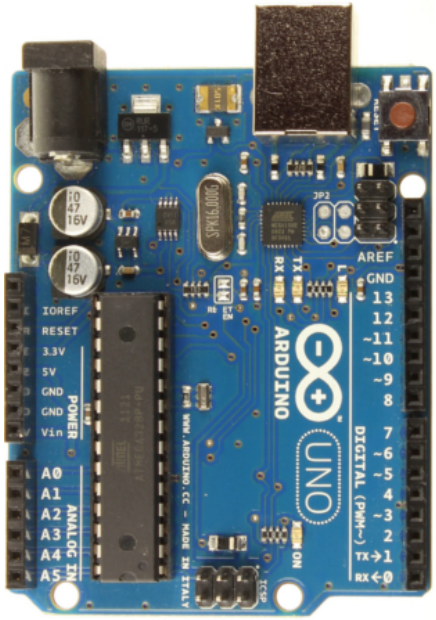


☐ ☐ ☐
3 Blocks for structure

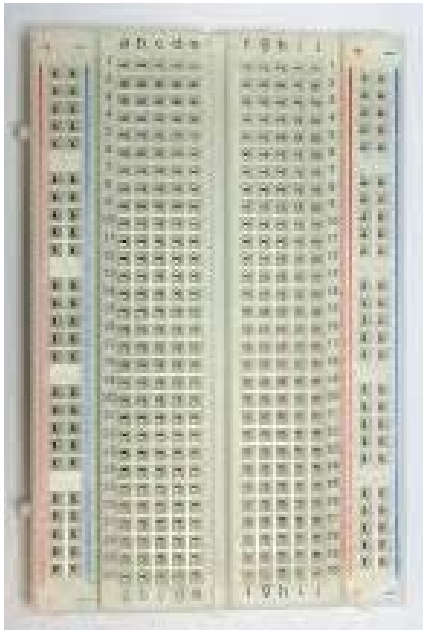
☐
Particulate Matter (PM) Sensor



☐ Arduino computer

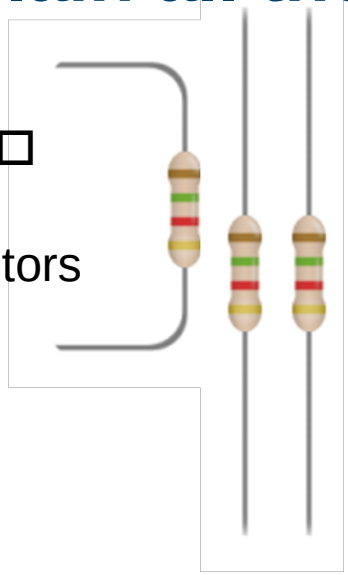


☐ Breadboard for wiring electronics



4. Explain all the kit components

☐ ☐ ☐
3
Resistors



☐ Battery and clip
(you'll get this
last)

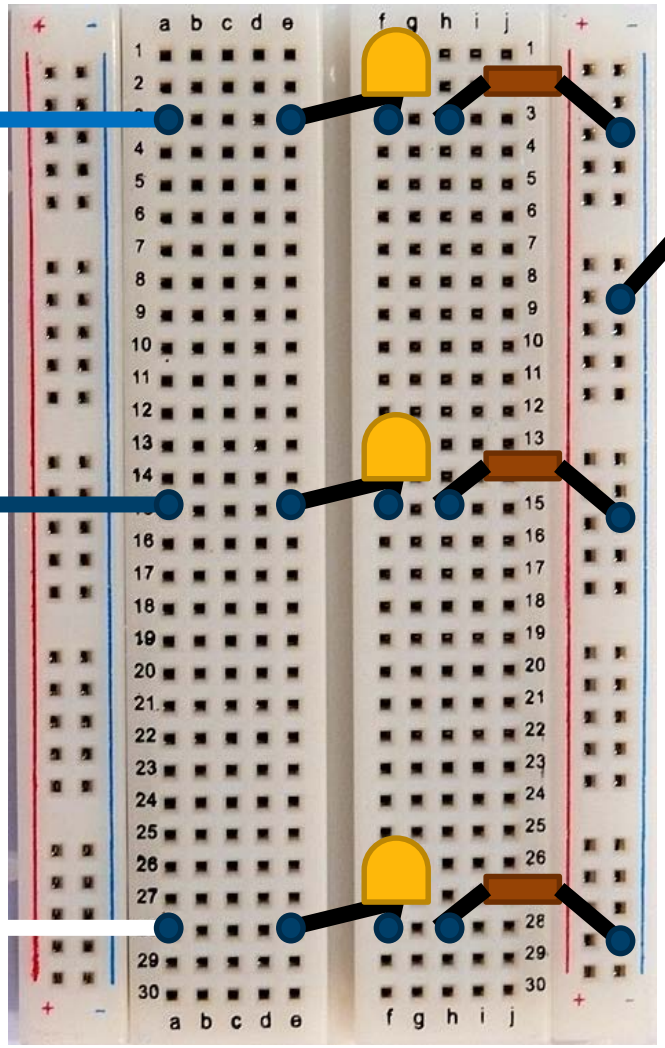
☐ ☐ ☐
3 LED
lights

LOOK:
one leg is
longer!

☐ ☐ ☐
☐ ☐ ☐
6 short
wires
☐
1 longer
wire

WIRE COLORS DON'T MATTER

5. Build!



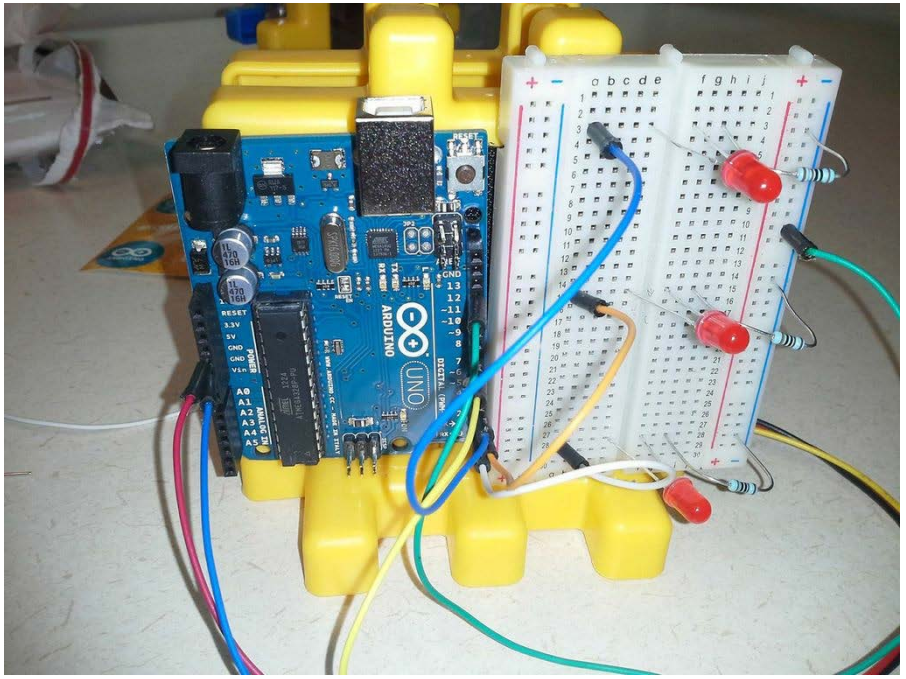
Breadboard Connections:

Blue wire: A3,~5 on Arduino
Orange wire: A15, 4 on Arduino
White wire: A28, ~3 on Arduino
Black wire: -, GND on Arduino
LED1: E3,F3
LED2: E15, F15
LED3: E28, F28
Resistor1: H3, -
Resistor2: H15,-
Resistor3: H28,-

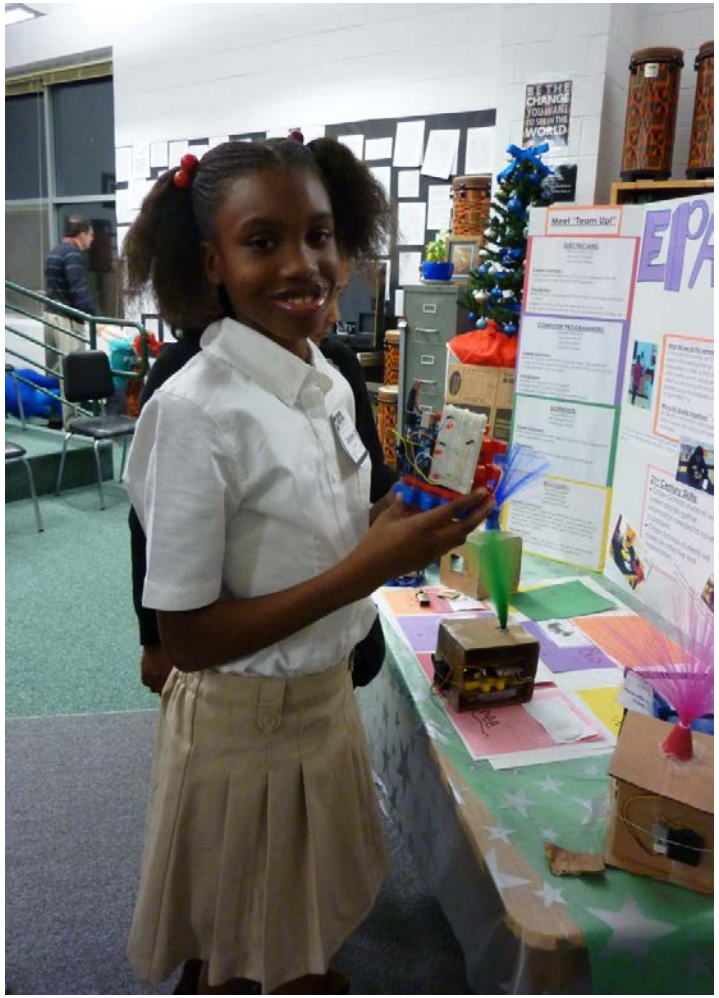
Notes:

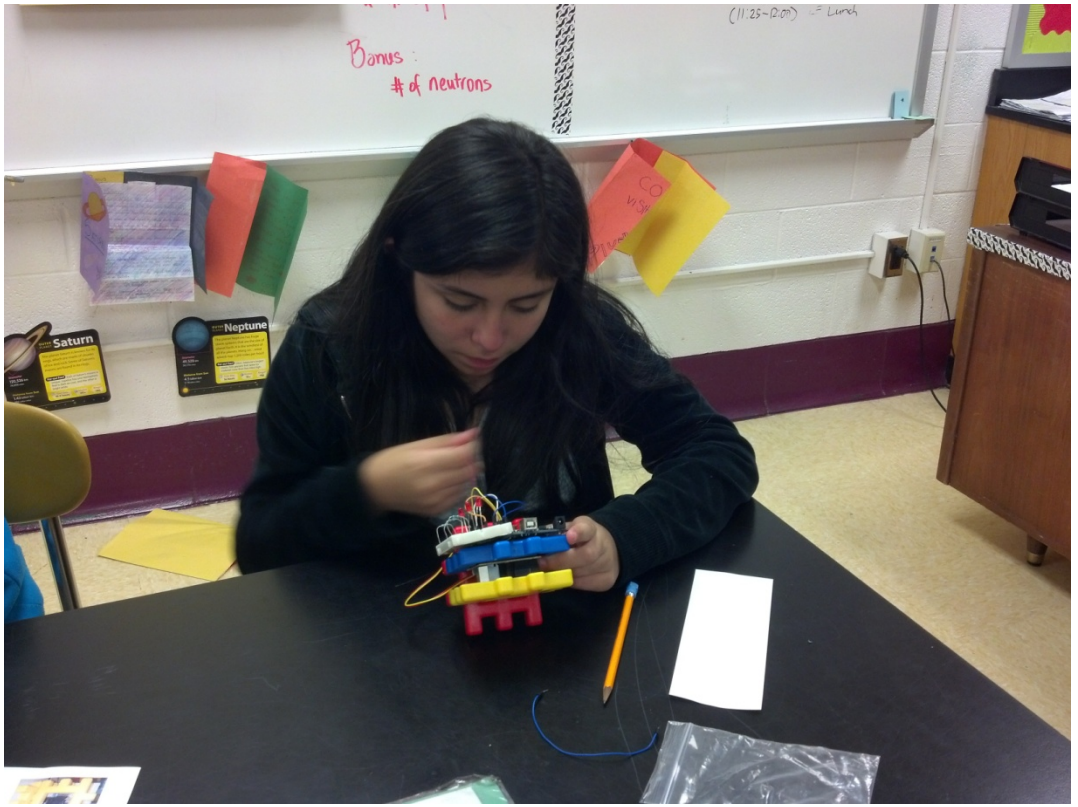
-All long legs of LEDs go in column E
-All short legs of LEDs go in column F
-Only plug into the Blue "–" bar on the right side of the breadboard

5. Build!

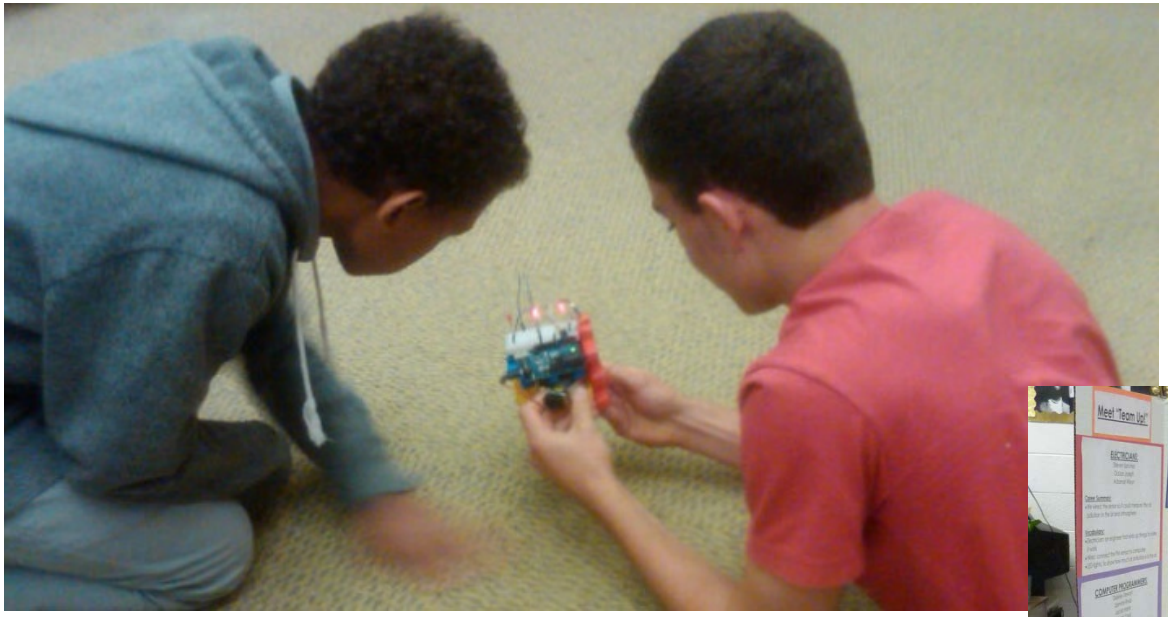


4. Build!


BE THE CHANGE YOU WANT TO SEE IN THE WORLD
Meet "Team Val"
EPA

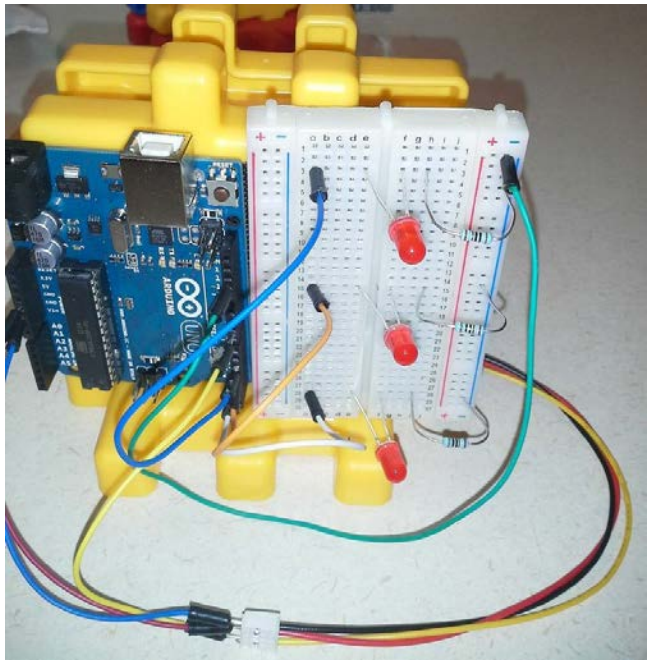

Bonus :
# of neutrons
Saturn
Neptune

6. What can we do to make the lights turn on?



Air sensor kit for outreach

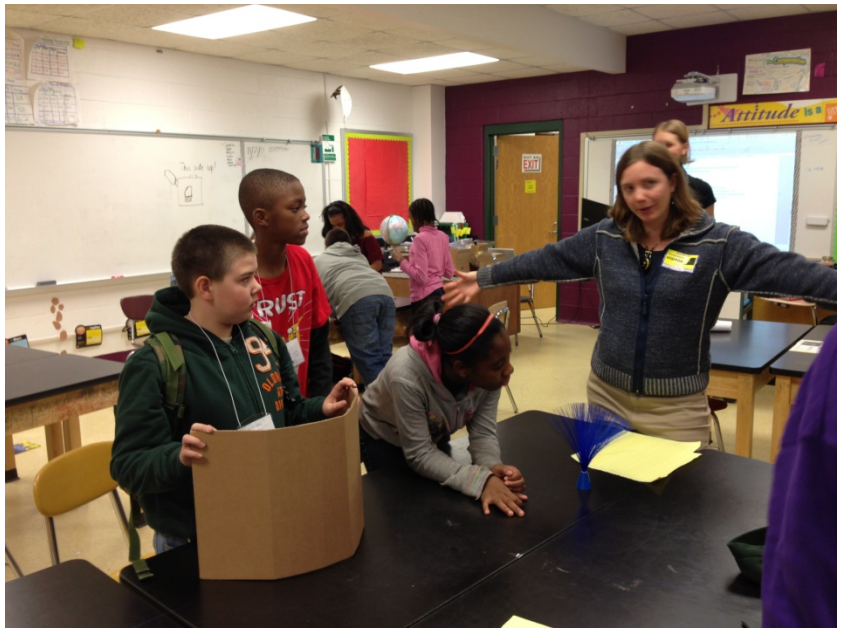
We've tried the kit with:
- EPA Air scientists and engineers
- EPA-RTP outreach volunteers
- Middle school students
- High school students
- Science teachers



Summary: Air sensor kit for outreach

Hands-on exploration of air quality science and electronics

Memorable and fun activity



Many ways to build out into a lesson plan series:

- Programming the Arduino board
- Trying to build other sensor systems
- Games to understand the basics of computer programming
- Designing new ways to show sensor readings

Do you want to incorporate this into your class?

We have:

- Instructions
- Arduino code ready to go
- Shopping list for parts
- Classroom handout

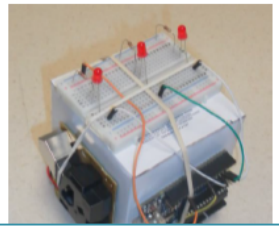
For more information:
Gayle Hagler:
hagler.gayle@epa.gov

Build Your Own Particle Sensor

Target Age Range: 5th -12th grades

Estimated Time: 1 hour
Additional ideas for lengthening the activity provided at the end. In addition, older high school age students can complete this activity in as little as 30 minutes with an abbreviated introduction.

Objective:
Teach basics about particulate matter air pollution and electronics. In addition work on problem solving and other science, technology, engineering, and math (STEM) skills.



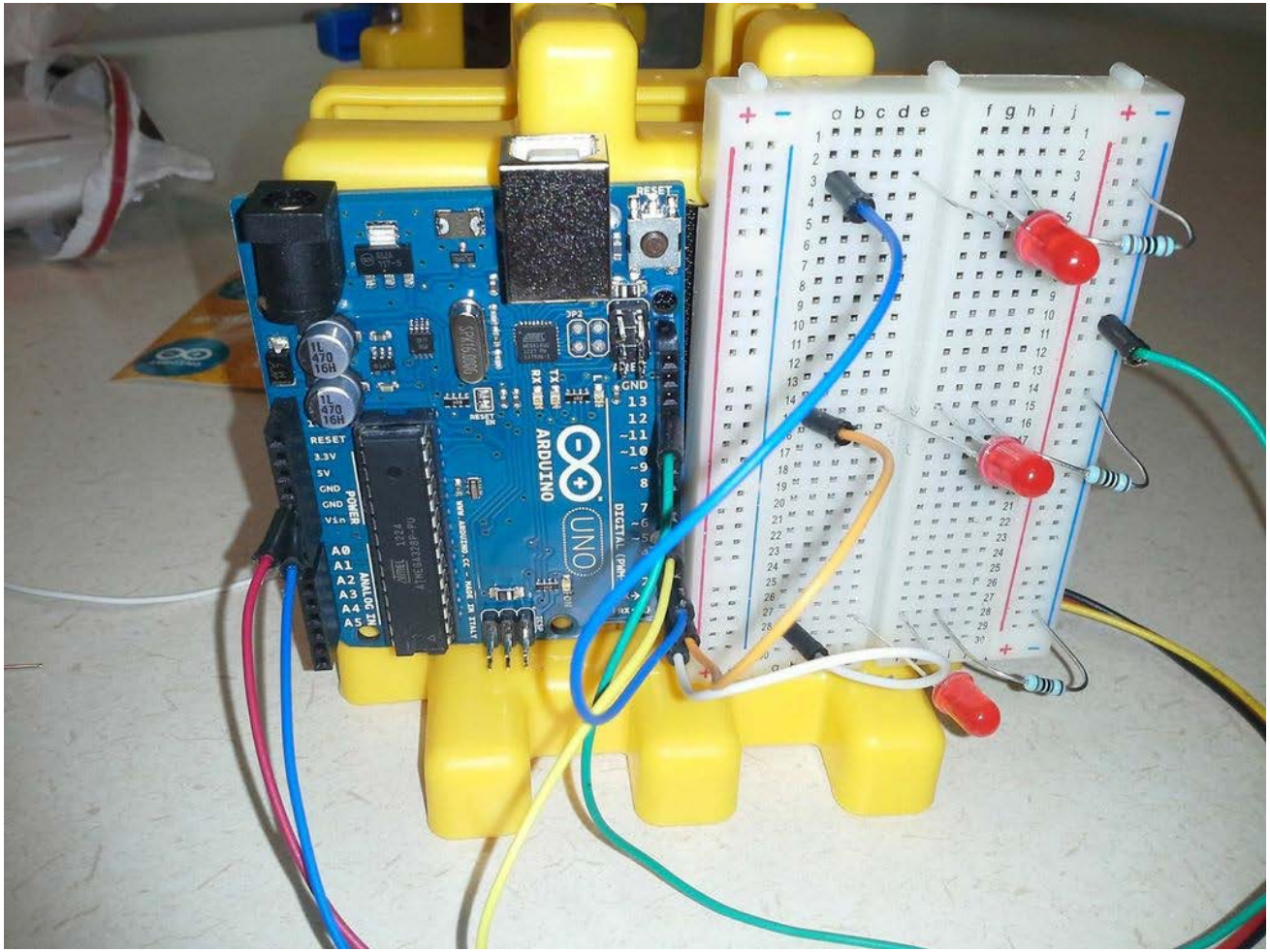
t components
children's building toy

Key components per kit:

Item (suggested source)	Number per kit	Cost
Arduino Uno R3 (adafruit.com)	1	$26.96
Half-size breadboard (adafruit.com)	1	$4.50
Breadboarding wire bundle (adafruit.com)	6 short wires, 1 long wire (1 wire bundle covers 10-15 kits)	$6.00
Diffused Red 5mm LED (25 pack) (adafruit.com)	3 LEDs (1 pack covers 6 kits)	$4.00
9V battery clip with 5.5mm/2.1mm plug (adafruit.com)	1	$2.70
1K Ohm resistor (digikey.com)	3	$0.04
Dust se		.00
9 V bat		00

http://www.wishlistr.com/sensorkit/

Now, let's build!



Acknowledgements

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Citizen Schools apprenticeship program students