NJ Science Convention
Demo Den 2009 Handouts

Tuesday Oct 13, 2009
1-D Motion Demos

Coffee Filter Demo:
Jim Ferrara, jferrara@shsd.org

Demonstrate the effects of Mass & shape on terminal velocity using coffee filters & a motion detector. Drop filters onto the motion detector from an appreciable height (ceiling) with the filters open, or scrunched up (alter shape), or try various numbers of filters to change mass.

Velocity & Accelerated motion Demo:
Jim Ferrara, jferrara@shsd.org

demonstrate Newton's 1st & 2nd Laws using several masses and a low-friction (pasco type) pulley & string to show various motions in 1D. Masses are first balanced at different heights on opposite sides of the pulley, then one is given a push to show const. velocity. Then rebalanced with a paper-clip added to show accelerated motion.

The Sound of Freefall
Dave Bandel, daranddave@optonline.net

A series of equally spaced washers are connected to a string that is approximately 2.5 m long.
One end of the string is connected to a baking sheet.
The other end is held by the demonstrator / volunteer while standing on a table or stool.
Prior to release, students may be asked to predict what will be heard. Quite often, there are a few
students who believe the time between each hit will be constant.
Once the string is released, the audience will hear each washer strike the baking sheet in decreasing
time intervals.
The students could then be asked how the washers would need to be arranged in order for the time
between each hit is equal. (The answer, of course, is with increased spacing.)
A second string of washers just happens to be attached to the baking sheet.
The positions of the washers relative to the baking sheet are **1**0, **4**0, **9**0, **16**0, and **25**0 cm.
Upon release, the students will now hear equal time intervals between washer hit upon the sheet.

Lab Practical Ideas for Motion in 1D

Dave Bandel, daranddave@optonline.net

At the conclusion of the topics constant velocity, constant acceleration, and freefall, student understanding can be assessed using a variety of lab practicals. For this activity, student groups are created by the teacher in order to be as equitable as possible with student abilities. The teams are assigned their activity through a random draw (I use dominoes.) The students have access to any pieces of equipment they used during their previous lab activities: spark timers, motion detectors, photogates and mini picket fences, rulers, meter sticks, and 2 meter sticks. The teams must develop their own procedure to analyze the equipment specified in their task. Their procedure and calculations may be hand written and must include a dimensional sketch of their equipment. Each component of their task may be analyzed independently but they may not perform any trial runs of the actual activity. When ready, the team will notify the teacher. Their performance is then recorded in order to closely assess the quality of the outcome and share the results with the class afterward.

A. Head-to-Head Constant Velocity Vehicles: The team is issued one 1 cell vehicle and one 2 cell vehicle. The vehicles start an assigned distance apart from one another. The team must analyze the motion of each vehicle separately and then predict where the two vehicles will meet.

B. Constant Velocity Vehicle Chase: The team is issued one 1 cell vehicle and one 2 cell vehicle. The vehicles start an assigned distance apart from one another with the 1 cell vehicle having a 'head start'. The team must analyze the motion of each vehicle separately and then predict where the 2 cell vehicle will be side by side with the 1 cell vehicle.

C. Freefall onto Constant Velocity Vehicle: The team is issued a constant velocity vehicle and a hard plastic ball. The ball must be dropped from an assigned height onto a bulls-eye target pulled by the constant velocity vehicle at floor level. The team must analyze the freefall and constant velocity vehicle separately. A piece of carbon paper will be placed on top of the target in order to obtain evidence of the outcome.

D. Freefall onto Constant Acceleration Vehicle: The team is issued a constant acceleration vehicle (a PASCO cart pulled by an assigned mass) and a hard plastic ball. The ball must be dropped from an assigned height onto the center of the accelerating vehicle. The team must analyze the freefall and constant velocity vehicle separately. When ready, a piece of carbon paper will be placed on top of the target in order to obtain evidence of the outcome.

E. Head-to-Head Constant Acceleration Vehicles: The team is issued two constant acceleration vehicles (PASCO carts pulled by different amounts of mass). The vehicles start an assigned distance apart from one another. The team must analyze the motion of each vehicle separately and then predict where the two vehicles will cross paths.

F. Head-to-Head Constant Velocity and Constant Acceleration: The team is issued one constant velocity vehicle and one constant acceleration vehicle. The vehicles start an assigned distance apart from one another. The team must analyze the motion of each vehicle separately and then predict where the two vehicles will cross paths.
Note: This scenario is the most challenging one algebraically due to the fact that an expression needs to be squared and the quadratic equation will need to be used as well.

Wednesday Oct 14, 2009
Circular & Rotational Motion

Intro Demos to circular motion
Jim Ferrara, jferrara@shsd.org

Bucket & Water in a string is twirled in a vertical circle & a motor car is tied to a string and taped to the floor and let go (in a direction that is perpendicular to the string taped to the floor).

Greek Waiter
Jim Ferrara, jferrara@shsd.org

A cup of water on a small platform is spun vertically in the air to demonstrate "centripetal" force.

Skater Spin
Jim Ferrara, jferrara@shsd.org

Weights and a spinning stool can be used to demonstrate conservation of angular momentum by spinning and moving the masses in each hand in & out.

ELECTRIC WIND TURBINE
Reg Hackshaw, EdD, rbh100@earthlink.net

Electric wind turbines run on the principle that forces acting between electric charges can produce mechanical movement. An early motor that incorporated this principle was conceived by Benjamin Franklin. Although modifications of what Franklin called his "electrical wheel" have been described over the centuries the basic operation remains the same.

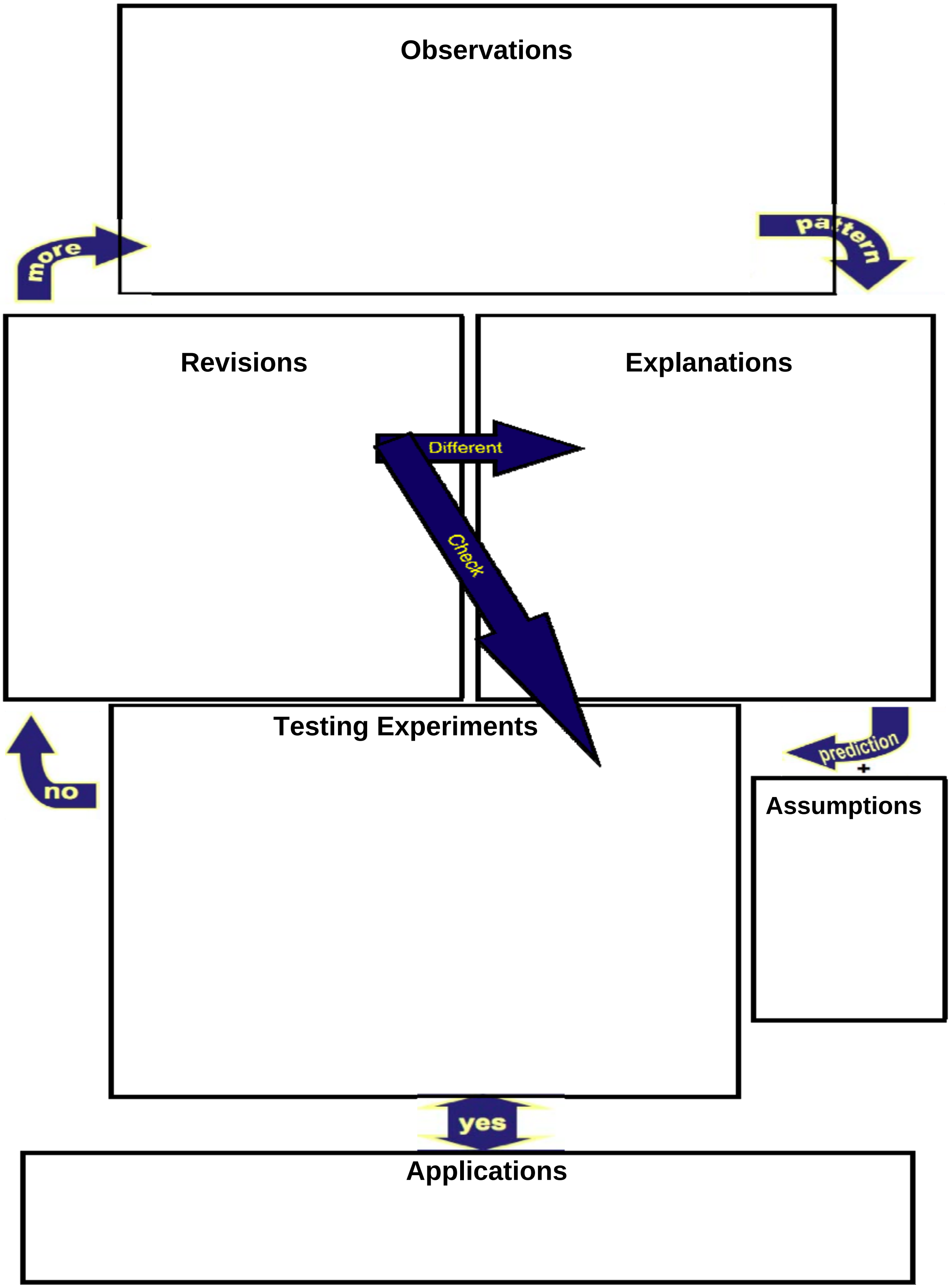
E-wind turbines consist of ionizing, high voltage electrodes that encircle a non-conducting, cylindrical rotor. Each electrode has a length-wise edge that sprays a breeze of either positive or negative ions on the rotor's surface. When the electrodes alternate in polarity around the rotor, each electrode repels a rotor segment carrying the same charge and simultaneously attracts that rotor segment carrying charges deposited by the preceding electrode.

Often, turbine designs described in the past required special materials as well as machine shop access. However, the parts for this educational, "green" project can made by re-purposing items usually tossed in recycling bins or sold at yard sales.

http://www.youtube.com/watch?v=cXD9W1LtG7A
http://www.youtube.com/watch?v=skgFyaGE5hA
http://f3wm.free.fr/sciences/jefimenko.html

The Investigative Science Learning Environment Approach to Circular Motion

Christine Osborne, *christine.osborne@millburn.org*



The Investigative Science Learning Environment Approach to Circular Motion

Observations: Take notes or draw pictures for each observation.

1. Roll a bowling ball rolls along a smooth floor in a straight line. As it moves, tap it with a rubber mallet in order to make it move in a circular path.

2. Swing a bucket at a constant speed in a horizontal circle.

3. Christine skates in a straight line at a constant speed. She approaches ____________ who grabs Christine's hand and rotates on an imaginary vertical axis through his/her body.

Analysis of Observations	List the objects that interact with the object moving in a circular path	Draw a free body diagram for the circling object	List forces or force components that balance	Indicate the direction of the unbalanced force exerted on the circling object
1. Bowling Ball				
2. Bucket				
3. Christine				

Patterns

Review the chart above. Based on your observations and your analysis, explain the pattern you observe for objects moving in circular paths.

Testing Experiments: Use the pattern you developed to predict the outcome of the following experiments. If your prediction is correct, your confidence in the pattern should increase. If your prediction is incorrect, you may have to reject the pattern, revise it, use it to make a better prediction, analyze your assumptions, and/or review the experiment.

1. Ball Constrained to a Ring
   (http://paer.rutgers.edu/pt3/experiment.php?topicid=5&exptid=57)
   A wooden ball is placed inside a large metal ring, which is on a flat surface. The ball is set into motion so it moves in a circular path. One part of the ring can be removed enabling the ball to escape from the ring. Based on your pattern, what should happen to the ball when it reaches the gap in the ring?

2. Pendulum Suspended from Spring Scale
   (http://paer.rutgers.edu/pt3/experiment.php?topicid=5&exptid=59)
   A ball hangs from a long string. The other end of the string is attached to a Newton force measuring scale. The string pulls up on the ball with a force of about 3 N, and the string and ball in turn pull down on the scale with a 3 N force. The scale reads 3 N. Suppose you pull the ball to the right so it swings like a pendulum. Predict whether the scale reading will read 3 N, less than 3 N, or greater than 3 N when the ball is directly under the scale.

Coat Hanger and the Penny:

Dave Bandel, daranddave@optonline.net

Straighten a wire hanger. Leave the 'hook' of the hanger in tact such that it creates a candy cane shape. Sand or grind the end of the hook so it is flat. The other end of the wire hanger should be bent into a loop so it is slightly larger than your index finger. For optimum performance, some baby powder or corn starch should be sprinkled on the index finger. Place the loop end of the hanger on your index finger. For the first trick, balance a penny on the hook end of the hanger. For the second trick, begin swinging the hanger and penny back and forth until the penny and hanger are able to spin in a complete circle. As the penny spins in its circular path, the hook of the hanger points in the direction of the net, or centripetal, force (toward the center of the circle). For the final trick, bring the hanger and penny to rest without having the penny fall off. This part requires quite a bit of practice.

Downy Ball on a String:

Dave Bandel, daranddave@optonline.net

A Downy fabric softener ball is attached to a string. When spun in a vertical circle at an increasing rate, the plug will pop out when the ball is at the bottom of the circle. This reinforces the fact that the net force / tension / centripetal force is greatest at the bottom since there wasn't enough force present at the top of the loop to cause the plug to pop.

Tennis Ball on a String:

Dave Bandel, daranddave@optonline.net

This one is just a handy item to have around as a visual aid when discussing circular motion. Cut a slit in a tennis ball with a box cutter. Tie a large knot in the end of the string and then force it into the slit. Whirl the ball over head or in a vertical circle as needed during the discussion.

Ping Pong Ball in a Funnel:

Dave Bandel, daranddave@optonline.net

A Ping Pong ball spun around inside a funnel can be used as a visual aid when discussing frictionless banked turns. As the funnel is spun faster, the ball moves to a larger radius. The visual aid helps students recognize that the net, or centripetal, force is the same as the horizontal component of the normal force. This will also make the derivation of the equation

$v = (rg \tan \theta)^{0.5}$ a bit easier.

Sewing Hoop and Ball:
Dave Bandel, daranddave@optonline.net

This demo can either be done on a front desk with an overhead mirror or with the aid of an overhead projector. Cut off about 1/4 of a sewing hoop. Tape the remaining 3/4 piece to either the desk top or the overhead projector. Align an inclined ruler such that a marble or steel ball will enter the hoop tangent to the opening. Tape the ruler in place in order to repeat the release as needed. The hoop reinforces the idea that the net, or centripetal, force can be due to a variety of sources. In this case, the wall of the hoop is continually pushing on the ball toward the center of the circle. When the ball exits the hoop, there is no net force on the ball. As a result, the ball follows a straight line path tangent to the end of the hoop.

Spinning Tray and Dishes: This demo is a variation of the classic pail of water spun in a vertical circle. A 'tray' can be made from nearly any material – a piece of plexiglass, a cafeteria tray, etc. Attach a string to each corner of the tray and connect the ends together. This will serve as the 'handle' for the apparatus. Place something on the tray – a water filled cup or some other object. Begin swinging the tray back and forth until the entire apparatus can be made to spin in a vertical circle. The tray continually exerts a force directed toward the center of the circle. Attempt to bring the apparatus to rest with the cup of water or other object still upon the tray.

Wednesday Oct 14, 2009

Atomic & Modern Physics

Atom Smasher Demo

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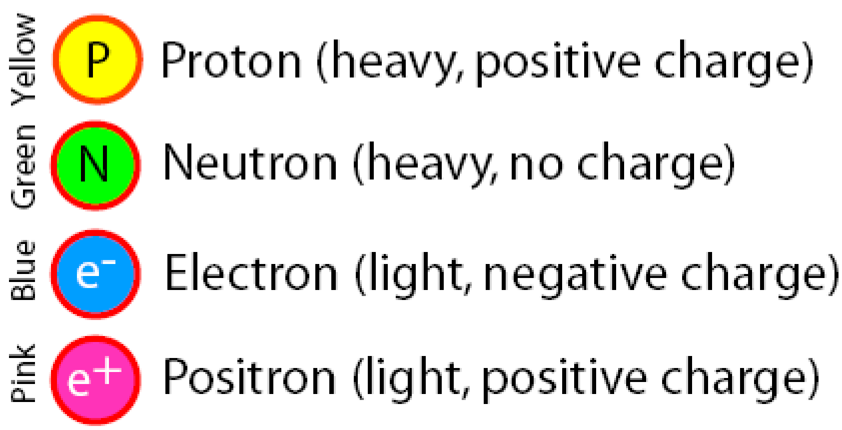
Fragmentation is the process by which nuclear research labs (like MSU-NSCL, http://www.nscl.msu.edu/) generate rare, radioactive isotopes.

The marbles are used to build nuclei and come in many colors, to represent different particles. They're defined in the photo and illustration below. The silver sphere in the photo is the super-strong magnet that helps hold your marble nuclei together. It doesn't actually represent a particle. This neodymium magnet is pretty powerful, be careful it can pinch your fingers!



NOTE: this is a model, not a fully-accurate representation of a nucleus!

With one set, you can create different particles, up to Carbon-12 (single electron/positron, single neutron, He-4 alpha particle, etc.). The particles are accelerated through the PVC pipe. The marbles dropped in the lower port will be called "low energy"; while those dropped in the upper port is "high energy".

When the marbles enter the plastic bin, they collide with a fixed target (usually Be-9, 4 protons and 5 neutrons).

What will happen if you hit the "target" with a low-energy "beam" proton? Try it, and describe the result. What will be different if you use a high-energy proton? Try it and describe the results.

What will change when you smash a He-4 "beam" into the Be-9, rather than just a proton? What do you think will happen to each nucleus (both beam and target)? Try it at low energy. Pick up the beam nucleus and pull off any marbles that aren't directly touching the silver one. Is it still He-4? If not, what is it now? Is your target still Be-9?

Build a C-12 nucleus (beam more massive than the target). How will smashing this beam into the target be different than when the beam was a proton or He-4 nucleus? Try it at low energy and describe the results. Were you right? What isotope is the beam nucleus now? Try that collision again at high energy. Was the collision different? What isotope is the beam nucleus now? Try C-12 at high energy two more times, recording what isotope the beam becomes. Does the beam nucleus come out the same each time you try this?

Visit the link http://www.nd.edu/~jina2/outreach/agreement.html for activities and lesson plans using the marbles nuclei.

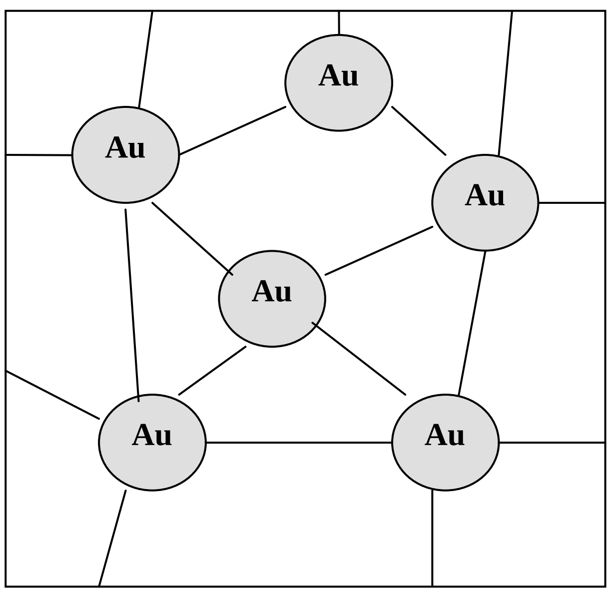
“**Shots in the dark**” – LAB (atomic structure)

Tiberiu Dagoiu-Luca, tdragoiu@gmail.com

Purpose: To study the atomic scattering by investigating the “size” of a target through the use of a model.

Materials: ruffle-balls (rubber stoppers), darkened goggles (blindfold), Rutherford experiment model,

Procedure:



Target area:

$A_{TARGET} = 6 \times \pi R^2$

Total model area:

A_{MODEL_BOX} = Width x Height (cm^2)

Width (cm) =

Height (cm) =

$$\frac{HITS}{TOTAL\_shots} = \frac{A_{TARGET}}{A_{MODEL\_BOX}}$$

Data/Calculations:

Student	TOTAL number of shots	Number of HITS	Radius-R (cm)	Uncertainty (%)
	14			
	14			
	14			
TOTAL:	42			

Class data	Total number of shots	Number of hits
Lab team A	42	
Lab team B	42	

Lab team C	42	
Lab team D	42	
Lab team E	42	
Lab team F	42	
Numbers per class:	252	

Find R (the "size" of the atom)

$$R = \frac{Width \times Height \times (HITS)}{6 \times \pi \times (TOTAL\_shots)}$$

Compare R with the "real" value.

$$\%error = \frac{|R_{EXP} - R_{ACTUAL}|}{R_{ACTAUL}} \times 100$$

Find the uncertainty: $\%Uncertaint\,y = \frac{\sqrt{TOTAL\_shots}}{Total\_shots} \times 100$

Ways of Luminosity

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- There are several ways that minerals can emit light, besides the light that is emitted from exposure to daylight or the light from normal light bulbs. Some of these ways involve special lamps that emit non-visible ultraviolet light (at least not visible to humans). The light from these ultraviolet lamps reacts with the chemicals of a mineral and causes the mineral to glow; this is called **fluorescence.**

- If the mineral continues to glow after the light has been removed, this is called **phosphorescence.**

- Some minerals will glow when heated; this is called **thermoluminescence.**

- There are some minerals that will glow when they are stuck or crushed; this is called **triboluminescence.**

- **Peizoelectric Effect**

How it Works

The fluorescent minerals are minerals that emit visible light when activated by invisible ultraviolet light (UV), X-rays and/or electron beams. Certain electrons in the mineral absorb the energy from these sources and jump to a higher energy state. The fluorescent light is emitted when those electrons jump down to a lower energy state and emit a light of their own.

The visible light emitted after being activated by UV light is sometimes very colorful and can often be very different from the normal **color** of the mineral.

Shortwave UV light is by definition of a shorter wavelength than the longwave UV light. Shortwave lamps which are available to collectors, can be very entertaining and useful to identify minerals, however it is dangerous to look at the shortwave light source (it can cause blindness) thus, they should not be used without adult supervision & great care.

Examples

Well over 3600 mineral species have been identified at this time. Something over 500 of them are known to fluoresce visibly in some specimens. Most minerals do not fluoresce when pure. It takes certain impurities in certain quantities to make the mineral fluoresce. Such impurities are called "activators". Different activators can make the same mineral fluoresce in different colors. Different minerals require different activators, and in different quantities. There are also impurities called quenchers, notably ferrous iron, that can prevent fluorescence despite the presence of an activator.

There are a few minerals that will fluoresce when pure. These are called "self-activated" minerals, and include **scheelite, powellite**, and several **uranium minerals**. Others suspected of being self-activated include **benitoite, cerussite, anglesite** and perhaps many other **lead minerals**.

Scheelite, a major ore of tungsten, is often found by its brilliant sky-blue fluorescence. If it has a little molybdenum in it (which makes it troublesome to extract the tungsten), this color is modified to white or yellow, providing a quick way to assess the commercial value of a find.

Several secondary uranium minerals, such as **autunite**, are also characteristically fluorescent a bright yellowish green. This is due to the **uranyl ion**; this ion is so prone to fluorescence that trace amounts of it cause yellowish-green fluorescence in a very large number of minerals, including **adamite, apophyllite, aragonite, calcite, quartz, and opal**. Any yellowish-green fluorescence other than **Willemite** is likely to be due to the uranyl ion.

A common fluorescent is **calcite**. It comes in just about all fluorescent colors due to different activators. Red and pink fluorescent calcites are often activated by a team of lead and manganese. Calcite may fluoresce green due to uranyl ion traces.

Fluorite gave its name to fluorescence, but that does not mean it is always fluorescent. Many fluorites fluoresce a blue-violet color due to traces of europium; this is usually best under longwave UV. Fluorite shows other colors of fluorescence in some cases.

Willemite, a zinc mineral, is often fluorescent a bright yellowish-green, due to traces of manganese.

Scapolite (wernerite) from Ontario and Quebec, Canada, fluoresces a vivid orangeish-yellow color under longwave UV, while shortwave UV inspires a long-lasting phosphorescence that can be markedly brightened by holding it under a running hot water faucet, illustrating thermoluminescence. Several other fluorescent minerals come from the same area, including **sodalite (hackmanite), cancrinite, diopside, fluoborite, and nepheline**.

Franklin, New Jersey is rightly known as the "fluorescent mineral capital of the world". Together with nearby Ogdensburg, it is the source of at least 260 minerals, of which at least 56 are fluorescent. Many of these minerals are found nowhere else in the world. Many of the fluorescents are uncommonly bright.