PHYSICS LABORATORIES 2023

Experimental physics motivates teachers and students to create new techniques and apparatus and to use them to demonstrate both old and new ideas. It is impossible, therefore, to anticipate all of the specific hazards that might arise in the study of physics. While it is not desirable to eliminate creativity in the interest of safety, teachers should temper their creativity with a constant alertness to potential dangers. Common sense can go a long way toward providing a safe environment.

Complete the Waste Disposal Form for removal of all waste (chemicals and broken glass) at the end of each semester. The Science/STEM Coordinator (Dr. Chaundra Creekmur; creekch@boe.richmond.k12.ga.us) will facilitate removal.

PHY 1: Required Materials for the High School Physics Lab

1. Broken Glass Container
2. Fire Extinguisher
3. Spill Kit
4. First Aid Kit
5. MSDS Notebook
6. Chemical Waste Disposal Containers

PHY 2: Eye Protection

Teachers owe their students a duty of care. A teacher must reasonably address all foreseeable dangers inherent in any laboratory experiment or demonstration that will be performed in the science laboratory or classroom. A teacher must also instruct and ensure that students demonstrate the proper use of protective equipment.

PHY 2.1 What is your obligation?

An important obligation of science teachers is to provide students with appropriate eye protection. **Provision and Maintenance of PPE - 29 CFR §1910.132(d) Personal Protective Equipment, General Requirements Standard** requires a hazard assessment to determine PPE needs and teachers must be trained in use and care of goggles.

PHY 2.2 What circumstances require eye protection?

Eye protection is a must in any hazardous laboratory activity or demonstration in science. Protection of the eyes is essential in any laboratory activity. Eye protection is required (but not limited to):

1. When chemicals, glassware, or a heating source is being used
2. When working with solid materials or equipment under stress, pressure, or force that might cause fragmentation or flying particles
3. When an activity generates projectiles, or uses elastic materials under stress, or causes collisions
4. When dust or fumes are present
5. When using preserved specimens

PHY 2.3 Choosing the best eye protection

Only safety goggles provide the level of protection needed for your laboratory activities when dealing with hazardous liquids or solids. A safety goggle fits the face surrounding the eyes; it should have a soft pliable flange, which seals around the eyes snugly to protect the eyes. In addition, safety goggles, with side shields or without side shields, provide adequate protection for laboratory activities involving use of solids such as meter sticks, projectiles, etc. Safety goggles should also be the standard for eye protection when chemicals, glassware, a heating source, or preserved specimens are being used.

PHY 2.4 Disinfecting Goggles

1. When using the safety goggle cabinet, the ultraviolet light timer should be set for a minimum of ten (10) minutes.. Sanitation of goggles is accomplished best by usage of a UV cabinet. Treatment with UV light will destroy the goggles over several years.
2. Hot soapy water and thorough drying between uses of shared goggles is also recommended by the ACS.

3. Chemical Disinfection: After student use, wash the goggles in soapy water followed by a ten (10) minute rinse in five percent bleach solution (10:1 ratio - 10 parts water to 1 part bleach). The goggles should be allowed to air dry.

PHY 2.5 What is the current recommendation for wearing contact lenses?

1. The American Chemical Society Committee on Chemical Safety states that contact lenses can be worn in the laboratory provided that approved eye protection is worn as required of others in the laboratory.
2. The National Institute for Occupational Health and Safety (NIOSH) recommends that workers be permitted to wear contact lenses when handling hazardous chemicals provided adequate face and eye protection is worn.
3. The Council of State Science Supervisors states that contact lenses can be worn provided "specially marked, non-vented safety goggles are available to contact lens wearers".
4. The Occupational Safety and Health Administration (OSHA) believes that contact lenses do not pose additional hazards to the wearer and has determined that additional regulation addressing the use of contact lenses is unnecessary.
    a. The agency wants to make it clear, however, that contact lenses are not eye protection devices. If eye hazards are present, appropriate eye protection must be worn instead of, or in conjunction with, contact lenses."
    b. Regulations (Preamble to Final Rules) Personal Protective Equipment for General Industry (Amended Final Rule, April 1994) Section 3- III Summary and Explanation of the Final Rule 1910.133 p. 16343.

PHY 3: Glassware

PHY 3.1 Injuries from Glassware

Glassware is the number one source of injury in the laboratory setting. More students are cut by damaged glassware and burned by heated glassware that are harmed by any other object or circumstance in the lab. To ensure the safety of students in the middle school laboratory, substitute plastic lab ware for glassware where possible. New plastics like polycarbonate (Lexan®) have been successfully used for laboratory containers. While not useful for heating, the plastic is clear and extremely hard and can be used for almost all water soluble compounds. Beakers, flasks, graduated cylinders, and thermometers now are available in plastic. Check with your science supply company.

PHY 3.2 General Cautions

PHY 3.2.1 Broken Glass

1. Use glassware that is without defect and has smooth edges.
2. One of the most important ways to prevent glassware related injuries is to check the pieces for chips or cracks. Any damaged glassware should be disposed of in the appropriate container.
3. Glassware should have no cracks, chips, or scratches. In particular, be wary of "star cracks" that can form on the bottom of beakers and flasks. Any glassware with such cracks should be properly disposed of immediately.
4. All glass tubing should be fire-polished.

PHY 3.2.2. "Frozen" Glass

Be careful with glassware that is "frozen." Only teachers, wearing goggles and gloves, should try to release the "frozen" glassware. If this fails, discard the glassware. Some common cases of "frozen" glassware are:

1. nested beakers that have been jammed together.
2. stoppers that cannot be removed from bottles.
3. stopcocks that cannot be moved.

PHY 3.2.3 Hot Glass

1. Use only Kimax® or Pyrex® brand glassware when heating substances. Common glass can break or shatter, causing serious injuries in the lab.
2. Use care when working with hot glass. Hot glass looks exactly the same as room temperature glass.
3. Do not leave hot glassware unattended, and allow ample time for the glass to cool before touching.
4. Check the temperature of the glassware by placing your hand near, but not touching, the potentially hot glass.
5. Have hot pads, thick gloves, or beaker tongs available for grasping hot glassware.
6. Never set hot glassware on cold surfaces or in any way change its temperature suddenly. Even a Pyrex® or Kimax® beaker will break if cold water is poured into a hot beaker.

PHY 3.2.4 Glass Tubing

1. Make sure that the tubing is without chips or cracks.
2. Use the appropriate diameter tubing for the task.
3. Make sure the ends of the tubing are fire polished.
4. When breaking tubing:
    a. Use gloves or towels to protect hands when breaking glass tubing. Use goggles to protect the eyes.
    b. Scratch the glass once with a file or score. Wrap the glass in a towel.
    c. Place the thumbs together opposite the scratch. Pull and bend in one quick motion.
    d. Fire polish the broken ends: hold the glass so that the sharp end is in the top of the flame of a gas burner. Rotate the tube so all sides are heated evenly, causing the sharp edges to melt and become smooth.
    e. Place the glass on insulating material to cool.

PHY 3.2.5 Bending

Bending glass tubing is often necessary. Follow these procedures:

1. Place a wing-top attachment on a gas burner and heat the area of the glass to be bent while holding it with one hand on each end, rotating to ensure even heating.
2. When the glass is soft and pliable, remove it from the flame and quickly bend to the desired shape.
3. Place on insulating material until cool.

PHY 3.3 Types and Appropriate Use of Glassware

To prevent glassware related injuries always use the correct type of glass for the task you are doing. For example, a graduated cylinder should be used to measure the volume of a liquid, not as a container in which to run chemical reactions. Likewise, a watch glass should not be used to mix chemical compounds, but as a cover over a heated reaction vessel.

PHY 3.3.1 Proper Use

Each type of glassware has its proper use and should be used only for its intended purpose.

1. **For measuring volume**:

pipets	burets	graduated cylinders
dropper pipets		volumetric flasks

2. **For storing solids and liquids:**

bottles	vials

3. **For containing reactive chemicals during experiments:**

beakers	flasks	test tubes
crucibles	watch glasses	test plates

4. **For transferring liquids and gases**:

   glass tubing funnels pipets

5. **For measuring temperature:**

   digital thermometers alcohol thermometers

PHY 3.5 Cleaning

1. Clean glassware immediately after use. The longer glassware sits, the harder it is to clean.
2. Use laboratory-grade detergents or liquid dishwashing detergent such as Dawn® for cleaning glassware.
3. When using brushes, make sure to use the appropriate size brush; make sure the metal part of the brush does not scratch the glass.
   Rinse glassware with deionized water.
4. Allow glassware to air dry on paper towels, drying pads, or drying racks.

PHY 3.6 Disposal

1. Use a dustpan and brush to pick up broken glass. Never pick up broken glass you're your bare hands.
2. Defective glassware should be disposed of correctly.
3. Glassware should be disposed of in a separate container from normal trash. Such container should be clearly labeled **BROKEN GLASSWARE ONLY.**

PHY 4: Common Hazards

PHY 4.1 Masses and Weights

1. Heavy masses may be used in experiments involving Atwood's machine, free fall, Newton's laws, and momentum.
2. Warning should be given to students to prevent hands and feet from being caught between a moving heavy mass and floor or table surfaces.
3. Masses or weights of no more than 500g should be given to the students. If heavier masses are required, then two or more masses of 500g each can be used.
4. When teachers or students are demonstrating Hooke's Law or Newton's Law, pieces of foam should be used to cushion the fall of masses or weights.
5. This will help avoid damage to the masses and also prevent the mass from rolling away.

PHY 4.2 Jet Action

1. Note that gas from carbon dioxide cartridges should be carefully released.
2. Make sure that the cartridge is under control and will not fly away and strike someone.
3. If wire guides are used for cartridge propulsion demonstrations, they should be securely fastened and pre-tested before use in the classroom.

PHY 4.3 Steam

1. Check the steam generating apparatus to assure that excessive pressures cannot develop before the steam is emitted.
2. Before each use, check safety valves on commercial apparatus such as pressure cookers and model steam engines in accordance with the manufacturers' instructions.
3. When generating steam in a test tube or flask, do not insert the stopper tightly or wire it down.
4. Caution students to direct steam outlets away from anyone's face.
5. Caution students exposed parts of the body out of the steam as steam can cause severe burns.
6. In set-ups involving the use of two or more valves, one must always be kept open.

PHY 4.4 High-speed Rotation

1. Rotators are sometimes used to demonstrate centripetal force, circular motion, and sound phenomena.
2. Any device attached to a rotator should be fastened securely and checked for tightness frequently.
3. Observers should avoid contact with moving accessories such as toothed wheels, siren discs, etc.
4. Loose clothing and long hair should be kept away from moving parts, and observers should not be in the plane of rotation.
5. The use of safety goggles should be considered in student laboratories investigating centripetal force.
6. Extremely high-speed rotation should be avoided when possible.
7. High speeds may cause some objects to fly apart unexpectedly.

PHY 4.5 Strobe Lights

1. A strobe light is sometimes used to illuminate a rotating object, making the object appear to be at rest.
2. If the object is a fan blade, a toothed wheel, or anything else with sharp edges, there is danger of injury from touching or inserting an object into the apparently stationary object.
3. Students should be cautioned against staring at the pulsating light for extended periods of time as this may create sensory disturbances in susceptible individuals.
4. Students prone to epileptic seizures should not participate in lab activities requiring the use of a strobe light; strobe lights are often used in clinical settings to induce seizures.

PHY 4.6 Magnets

1. Avoid heavy and very powerful magnets.
2. A powerful magnet can attract any loose steel object or fly to any stationary steel object hurting anyone in its path.
3. Avoid the use of iron filings that contain black iron powder.
    a. Black iron powder coming into contact with cuts can act as an irritant.
    b. Use magnetic chips or iron chips which are polished and free of dust.
    c. They can be purchased from science supply companies.

4. Safety goggles and disposable gloves should be worn while working with magnets and iron filings or chips.
5. Students should use long handled brushes to collect the iron filings or chips from the working area or lab bench.
6. All equipment should be brushed until iron free.

PHY 4.7 Tools

1. NEVER use a dull cutting tool. It may slip and cause serious injury.
2. Cut away from yourself when using any sharp instrument.
3. Cut sheet metal only with sharp shears.
4. File the edges smooth using a file or emery cloth.
5. Rest hot soldering irons on metal stands to avoid burns and prevent fires.
    a. Use pliers or clamps to hold wires and metals for soldering.
    b. Do not inhale fumes from soldering paste.
6. Power Tools
    a. It may be necessary for students constructing apparatus for physics experiments to use various power tools contained in a wood or metal shop.
    b. In these situations the industrial arts instructor should be consulted for proper safety precautions necessary for each tool or machine.

PHY 4.8 Projectiles

1. Students must be careful when projecting objects (steel balls or marbles).
    a. In demonstrating the flight of any projectile, students should be kept clear of the path and impact area.
    b. The teacher should always pretest the projectile to determine the path it will follow and its range as well as the amount of variability to be expected.
    c. Sharp-pointed objects should not be used as projectiles.
    d. Use of safety goggles is mandatory.

2. A simple mechanical launcher (e.g., compressed spring, compressed air, stretched elastic) should be used.
    a. It should only be "loaded" at the specific time a flight is to be observed.
3. Springs
    a. Stretched or compressed springs contain mechanical potential energy.
    b. A stretched spring, unexpectedly released, can pinch fingers.
    c. A compressed spring, when suddenly released, can send an object at high velocity toward an observer.
    d. Care should be taken to avoid unexpected release of the spring's energy when working with dynamics carts, spring-type simple harmonic oscillators, and springs used in wave demonstrations.

PHY 4.9 Capacitors

1. Capacitors are used to store electric charge.
    a. They may remain charged for long periods after power is turned off, and they therefore pose a serious shock/burn hazard.
    b. Before working on any circuit containing a capacitor, make sure that it is discharged by shorting its terminals with an insulated wire or screwdriver.
    c. Oil-filled capacitors may sometimes recharge themselves and should be kept shorted when not in use. Oil from older capacitors may be contaminated with dangerous PCBs.
2. When installing electrolytic-type capacitors in a circuit, proper polarity rules must be followed (negative to negative and positive to positive). Improper connection can result in an explosion.
3. Be on the lookout for capacitors in any apparatus with high voltage components such as oscilloscopes, TV sets, lasers, computers, and power supplies.
4. Electrostatic generators and Leyden Jars are also capacitors and can be a source of unexpected shock.

PHY 4.10 Electrostatic Generators.

1. Electrostatic generators used in demonstrations of static electricity produce high voltages (about 105 volts) with very low currents.
2. The danger of these generators depends on their size and capacity to produce enough current to be dangerous.
    a. In many cases the shock from such devices is very quick and not harmful.
    b. The startling effect, however, can be detrimental to persons with heart conditions.
    c. In general, experiments that use human subjects to demonstrate the effect of electrical shock should not be attempted due to the large variation in physical and physiological factors.
    d. Leyden jars -- which can be charged with electrostatic generators -- are especially dangerous because of their capacity to store a charge for long periods of time.
    e. An accidental discharge through a person can be avoided by properly shorting the devices after use

PHY 4.11 Heating Procedures

Often it is necessary to heat liquids and solids in physics experiments and demonstrations. It is safer to use water baths and hot plates than to heat directly with open flames such as with Bunsen burners. Below are guidelines for heating and handling hot objects.

1. Any glass apparatus that is to be heated should be made of Pyrex® brand or Kimax® brand. It must be free of chips and cracks.
2. Gas burners should be kept away from the body at all times.
    a. The pressure of the gas should be adjusted to allow proper ignition.
    b. Too high a pressure tends to blow the flame out.
    c. Do not allow gas to accumulate if ignition is delayed for any reason.
3. Never heat a closed container if there is no means of pressure relief.

4. Many substances, especially glass, remain hot for a long time after they are removed from the heat source.
    a. Always check objects by bringing the back of the hand near them before attempting to pick them up without tongs, hot pads, or gloves.
    b. Never set hot glassware on cold surfaces or in any other way change its temperature suddenly, because uneven contraction may cause breakage.

PHY 4.12 Cryogenics

1. Dry ice (solid carbon dioxide) is used in some low-friction pucks, as a source of carbon dioxide gas, and as a cooling agent.
2. A mixture of dry ice and alcohol or liquid nitrogen might also be used as low-temperature baths.
    a. The temperatures of these materials are low enough to cause tissue damage from a cryogenic "burn."
    b. This is not likely to occur if contact is brief, because the vapor layer formed between the cryogen and the tissue is not a good conductor of heat.
3. Follow the guidelines below to avoid a dry ice "burn."
    a. Flush the skin that came into contact with the dry ice with water.
    b. Water should always be readily available during cryogenic experiments.
    c. In preparing a dry ice/alcohol mixture, pour the alcohol over the dry ice rather than dropping the dry ice into the alcohol to avoid spattering.
4. When storing alcohol that has been used in a dry ice/alcohol mixture, the alcohol should be returned to room temperature to allow the escape of excess dissolved gas before placing in a closed container.
5. When dry ice is used in a confined space, provide sufficient ventilation to eliminate the risk of asphyxiation.
    a. This risk is caused when the more dense carbon dioxide gas released produces an oxygen-deficient layer.
    b. Dry ice may produce large amounts of carbon dioxide. Students and other teachers should be warned of this risk and informed about avoiding it.

6. Cryogens should be kept in double-walled containers such as Thermos bottles or Dewars.
    a. Any fluid which gets between the walls at low temperatures may become trapped and vaporize at higher temperatures, building up pressure and exploding the container.
    b. The outer wall should be heavily wrapped to avoid this hazard.

PHY 4.13

PHY 4.13.1 Compressed Gases

Compressed gases can be hazardous because each cylinder contains large amounts of energy and may also have high flammability and toxicity potential. The following is a list of recommendations for storage, maintenance, and handling of compressed gas cylinders.

PHY 4.13.1.1 Compressed Air

1. Students in laboratories equipped with compressed air at lab stations or lecture tables should be warned of the danger of blowing dust or other debris into the eyes accidentally with compressed air.
2. High pressure air directed at glassware for drying purposes can provide enough force to knock containers from the hands.
3. The flow of air should be adjusted first to prevent this hazard.

PHY 4.13.2 Care of Compressed Cylinders

PHY 4.13.2.1 Labels

1. Make sure the contents of the compressed gas cylinder are clearly stenciled or stamped on the cylinder or on a durable label.
2. Do not identify a gas cylinder by the manufacturer's color code.
3. Never use cylinders with missing or unreadable labels.
4. Label empty cylinders ―EMPTY‖ or ―MT‖ and date the tag; treat in the same manner that you would if it were full.

PHY 4.13.2.2 Operations

1. Check all cylinders for damage before use.
2. Be familiar with the properties and hazards of the gas in the cylinder before using.
3. Wear appropriate protective eyewear when handling or using compressed gases.
4. Use the proper regulator for each gas cylinder.
5. Do not tamper with or attempt to repair a gas cylinder regulator.
6. Never lubricate, modify, or force cylinder valves.
7. Open valves slowly using only wrenches or tools provided by the cylinder supplier directing the cylinder opening away from people.
8. Check for leaks around the valve and handle using a soap solution, ―snoop‖ liquid, or an electronic leak detector.
9. Close valves and relieve pressure on cylinder regulators when cylinders are not in use.

PHY 4.13.2.3 Transport

1. Always attach valve safety caps when storing or moving cylinders.
2. Transport cylinders with an approved cart with a safety chain; never move or roll gas cylinders by hand.

PHY 4.13.2.4 Storage

1. Securely attach all gas cylinders (empty or full) to a wall or laboratory bench with a clamp or chain, or secure in a metal base in an upright position.
2. Store cylinders by gas type, separating oxidizing gases from flammable gases by either 20 feet or a 30-minute firewall that is 5 feet high.
3. Store gas cylinders in cool, dry, well-ventilated areas away from incompatible materials and ignition sources.
4. Do not subject any part of a cylinder to a temperature higher than 125 °F or below 50 °F.
5. Store empty cylinders separately from full cylinders.

PHY 4.14 Sound

1. Usually physical science laboratory equipment and activities do not normally produce noise levels requiring use of hearing protection.
2. The OSHA Occupational Noise Standard (29 CFR 1910.95) has established a noise action level of 85 decibels (dBA) averaged over eight hours.
3. Wind tunnels, motors, engines and other laboratory equipment used in physical science laboratories have the potential to exceed the action level.
4. Science teachers should monitor sound levels and provide hearing protection for themselves and students.
5. It is advised that this be applied even below the action level.

PHY 5: Radiation

PHY 5.1 Ionizing Radiation

1. **The use of ionizing radiation sources in high school science laboratories is not allowed.**

PHY 5.2 Non-Ionizing Radiation

Near ultraviolet, visible light, infrared, microwave, radio waves, and low-frequency radio frequency (longwave) are all examples of non-ionizing radiation. By contrast, far ultraviolet light, X-rays, gamma-rays, and all particle radiation from radioactive decay are regarded as ionizing. Non-ionizing radiation can produce non-mutagenic effects such as inciting thermal energy in biological tissue that can lead to burns. Recently, the International Agency for Research on Cancer (IARC) from the WHO (World Health Organization) released a statement indicating that radiofrequency electromagnetic fields (including microwave and millimeter waves) are possibly carcinogenic to humans.

PHY 5.2.1 Infrared Radiation

1. Caution students that, beyond a limited exposure, infrared waves (heat waves) entering the eye can cause burns to the cells of the retina. Infrared lamps and the sun are concentrated sources of these waves.
2. Follow manufacturer's instructions when using any infrared lamp.
3. The sun should never be viewed directly, especially at times when its visible light is partially obscured.
    a. Lenses and sunglasses do not offer protection from this radiation.
    b. Safe viewing of the sun can be done by projecting an image of it through a very small hole onto a white piece of paper about one-half meter behind the hole.

PHY 5.2.2 Microwaves

A microwave apparatus is often used to demonstrate various wave behaviors of electromagnetic radiation. Microwave devices designed for high school use have sufficiently low power to be free of radiation hazards when the manufacturer's instructions are followed. Follow these guidelines:

1. RCSS policy forbids the use of microwaves in any classroom.
2. When using a microwave oven anywhere in the building
    a. Check the apparatus for radiation leakage before use if there are any doubts about its safety.
    b. Inspect ovens periodically to ensure they are clean and the door, hinges, vision screen, seals, and locks are secure and working properly.
    c. Do not place metal objects in the heating cavity.
    d. Do not permit students to stand close to an oven during operation.

PHY 5.2.3 Radioisotopes

The use of radioisotopes is forbidden in RCSS laboratories.

PHY 5.2.4 Ultraviolet Radiation

PHY 5.2.4.1 Sources

1. Sources of harmful ultraviolet light likely to be encountered in physics include mercury vapor lamps, electrical arcs (e.g., the carbon arc lamp), incandescent ultraviolet lamps, and the sun.
    a. Mercury vapor lamps and electric arcs should not be observed without elimination of their ultraviolet emissions.
2. Incandescent ultraviolet lamps present a minimal danger from their ultraviolet emissions, as the energy of this radiation is very low.

PHY 5.2.4.2 Personal Protection

1. Protect eyes and skin from exposure of ultraviolet transilluminators.
    a. Ultraviolet light can be absorbed in the outer layers of the eye, producing an inflammation known as conjunctivitis.
    b. The effect usually appears several hours after exposure and, unless the exposure is severe, will disappear within several days.
    c. Special glasses (such as those coated with an ultraviolet absorbing film) should be used when examining mineral samples with an ultraviolet lamp.

d. Only special goggles clearly designated for the purpose of absorbing ultraviolet light should be used.
e. Plastic or glass sheets which transmit poorly in the ultraviolet region offer good protection for the viewer of these sources.
f. Use black paper with caution because, while it absorbs well in the visible range, it may be highly reflective in the ultraviolet range.

2. Wear long sleeve shirts and lab coat with gloves.

PHY 5.2.4.3 General Operating Considerations

3. Maintain the illuminator in a room dedicated for the use of UV light.
   a. Make sure the appropriate hazard warnings are posted prominently on the outside of the door.
   b. The room should remain locked when not in use.
4. Only use a ground-fault circuit interrupter (GFCI) protected electrical receptacle for the lamp.
5. Never operate the lamp near water sources.
6. Never disassemble the lamp when plugged in – this is a high voltage power supply device.

PHY 5.2.5 X-ray Radiation

Any device that has the potential for producing X-rays is forbidden in RCSS laboratories.

PHY 6: Laser Safety

Although high-powered lasers can punch holes through concrete blocks and steel, there are no documented reports of anyone being hurt by a laser beam of 10 milliwatts or less. All lasers should be used with caution and common sense. The lasers that are most useful for teaching science are those that emit low-power continuous-wave visible beams (wavelengths ranging from 400 to 700 nanometers). For special demonstrations or students' projects that require other types of lasers, close supervision by trained and knowledgeable personnel is important to avoid safety hazards.

1. All lasers used in schools must comply with the Laser Performance Standard of the U.S. Department of Health and Human Resources and with Title 21, Part 1040 of the Code of Federal Regulations http://www.access.gpo.gov/nara/cfr/waisidx_00/21cfr1040_00.html.
2. These regulations specify safety features and classify lasers into four classes.
3. The least dangerous is Class 1, the most dangerous is Class 4.
4. **CAUTION: ANY LASER WITH A RATING ABOVE CLASS 2 BE REMOVED FROM THE SCHOOLS, AND IT IS ALSO STRONGLY RECOMMENDED THAT STUDENTS NOT BE ALLOWED TO OPERATE ANY LASER ABOVE CLASS 1.**
5. Class 1. The power of a beam emitted by a Class 1 laser (below 0.4 microwatt) presents very little risk of damage to any part of the human body.
6. Class 2. The beam emitted by a Class 2 laser (visible light 0.4 microwatt to 5 milliwatts) is not considered hazardous to the skin regardless of the exposure time.
    a. However, because of the beam's dazzling brightness, a long exposure can present hazards to the eyes.
    b. Normal eye reflexes automatically prevent exposures longer than 0.25 second.
    c. However, an intentional exposure of fifteen minutes or more, by deliberately staring into the beam, is considered hazardous and should never be allowed. The following have been determined to be unsafe for school use.

PHY 7: Electrical Hazards

PHY 7.1 Burns and Shock

1. Many electrical devices become quite hot while in use.
    a. In addition, "shorted" dry cells and batteries can produce very high temperatures.
    b. Students should never grasp a recently operated device or wiring without first checking for excess heat.
2. Students must be warned of the high death potential present even when the voltage is low.
    a. The severity of an electrical shock depends primarily on the amount of current to which a person is exposed.
    b. Since the current is related to the resistance and voltage, these two factors, as well as the part of the body involved and the duration of the contact, determine the extent of injuries to the victim.
    c. If the skin is wet or the surface broken, the resistance drops off rapidly, permitting the current to flow readily through the bloodstream and body tissues.

PHY 7.2 Electrical Apparatus

PHY 7.2.1 Batteries

1. A battery is an unregulated source of current capable of producing large currents when resistance is low.
    a. When short-circuited, connecting wires can become very hot, raising the risk of burns. Short-circuited mercury batteries may even explode.
    b. Chemical leakage from batteries is a potential hazard, especially in the case of wet cells that contain caustic chemicals such as sulfuric acid.
2. Certain types of batteries are rechargeable while others are not.
    a. Carbon-zinc and nickel-cadmium type batteries can be recharged.
    b. Do not, however, attempt to recharge a completely dead carbon-zinc battery, a leaking or corroded battery, or any battery that carries a warning against recharging.

c. Such batteries can cause damage to the charger and may explode, causing personal injury. Lead-acid batteries can be recharged but produce explosive hydrogen gas during the process.
d. They should only be recharged in a well-ventilated area with an appropriate charger.

3. Do not discard any battery in the trash.
4. Contact Facilities and Maintenance for pick-up and disposal. Document the date of the request and the date the pick-up occurred.

Complete the Waste Disposal Form for removal of all waste (chemicals and broken glass) at the end of each semester. The Science/STEM Coordinator (Dr. Chaundra Creekmur; creekch@boe.richmond.k12.ga.us) will facilitate removal.

PHY 7.2.2 Circuit Loads

1. Most school laboratory electrical circuits have a maximum power rating of 1,500 watts (if fuses are 15 amp) or 2,000 watts (if fuses are 20 amp).
2. The total power load on a circuit should not exceed these values.
3. The total load is the sum of the power ratings of all apparatus plugged into that circuit.
4. The individual power rating is usually found printed on a plate somewhere on the apparatus.

PHY 7.2.3 Extension Cords.

1. Use extension cords only when there is no convenient way to connect equipment directly to a receptacle.
2. If an extension cord must be used, it should be checked for damage, proper grounding, and electrical capacity.
3. An extension cord should be marked with its capacity in amperes and watts and the total load should not exceed these values.
4. If the cord is unmarked, assume that it is 9 amperes or 1,125 watts.
5. If an extension cord becomes very warm to the touch, it should be disconnected and checked for proper size.

6. In general, science laboratories should be equipped with sufficient receptacles to minimize extension cord use.

PHY 7.2.4 Fuses/Circuit Breakers.

1. Replace blown equipment fuses with fuses of the same amperage.
2. Replace fuses with the equipment unplugged.
3. Failure to use the correct fuse can cause damage to equipment and overheating.
4. Frequent blowing of circuit fuses or tripping of circuit breakers usually indicates that the circuit is overloaded or a short exists.
5. Circuit breakers and fuses that are tripped or blown should be turned on or replaced only after the cause of the short or overload is removed from the circuit.

PHY 7.2.5 Grounding

1. Use grounded 3-prong plugs when available.
2. If the outlet is 2-prong, use an adapter and secure the ground wire to the cover-plate screw on the outlet.
3. Any apparatus with a metallic case or exposed metal parts should be checked to make sure that the case is grounded.
4. Such ungrounded appliances should be retrofitted with a ground wire and three-pronged plug.
5. The use of ground-fault interrupters should be considered.

PHY 7.2.6 Power Cords

1. Any power cord should be inspected periodically and replaced immediately if frayed or damaged.
2. Apparatus should be located to keep power cords away from student traffic paths.
3. When removing the cord from an outlet, the plug should be pulled, not the power cord.
4. Wet hands and floors present a hazard when connecting or disconnecting electrical apparatus.

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PHY 8: Vacuum and Pressure Hazards

PHY 8.1 Vacuums

1. Full face shields should be worn whenever working with a system which could conceivably implode or explode.
2. Many popular physics demonstrations utilize a small vacuum pump to evacuate a chamber such as a bell jar, a coin-feather tube, or a collapsing metal can.
    a. Under no circumstances should a standard thin-walled, flat-bottom jar be evacuated because of the likelihood of implosion.
    b. If students are to be allowed to pump out a well-designed chamber, make sure it is firmly mounted so it cannot tip over and implode when under vacuum.
3. Any large evacuated chamber should be equipped with a screen shield to help provide protection following an implosion.
    a. Such implosions can result from long-term stresses in glass or may result from thermal effects if heating occurs without opportunity to expand.
    b. On small chambers where a screen is inconvenient or undesirable, the walls should be wrapped with tape to reduce the flying glass following an implosion.
4. When bell jars are used in demonstrations, remind students that they are specifically designed to withstand atmospheric pressure, and that one should never pump on a conventional container.

PHY 8.2 Tubes and Implosions.

1. Safety goggles or shields should be worn by all observers.
2. Vacuum tubes, especially large ones, present a safety hazard if the tube breaks.
    a. Flying glass and electrodes can travel great distances when a tube implodes.
    b. This is a particular danger when tubes such as a cathode ray tube, a TV picture tube, or a Crookes tube are used in a demonstration or experiment that removes them from a protective housing.

c. When an inoperable tube is to be discarded, it should be covered with a heavy canvas cloth and broken by striking the rear of the tube with a hammer.
d. The broken tube should then be carefully disposed of in the BROKEN GLASS CONTAINER!!!

PHY 8.3 Vacuum Pumps.

1. Vacuum pumps equipped with belts and pulleys must have the belt and pulley system shielded to prevent clothing and hands from getting caught.
2. This shield should also prevent injury from broken belts striking nearby observers.
3. Students should be warned to be careful of the hot motor and other parts after operation.

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PHY 9: Rocketry

PHY 9.1 Local Regulations

Before beginning a model rocket program, check local school system regulations on the use of model rockets. Be sure also to check regulations about launch sites and fire codes in your area (See NFPA 1122 @ http://www.nfpa.org)

PHY 9.2 Model Rocketry Safety Code

1. **Construction.** In making model rockets, use only lightweight materials such as paper, wood, plastic, and rubber; use no metal as structural parts.
2. **Engines**. Use only pre-loaded, factory-made model rocket engines in the manner recommended by the manufacturer. Do not alter or attempt to reload the engines.
3. **Flying Conditions**. Do not launch a rocket in high winds or near buildings, power lines, tall trees, low flying aircraft, or under any conditions that might endanger people or property, such as the threat of lightning.
4. **Jet Deflector**. The launcher must have a jet deflector device to prevent the engine exhaust from hitting the ground directly.

PHY 9.2. Launch

1. Check the stability of model rockets before their first flight, except when launching models of proven stability.
2. Model rockets must weigh no more than 453 grams at liftoff, and the engine must contain no more than 113 grams of propellant.
3. When conducting research activities with unproven designs or methods, try to determine their reliability through pre-launch tests.
4. Conduct launching of unproven designs in complete isolation from persons not participating in the actual launching.
5. Always launch rockets from a cleared area that is free of any easy-to-burn materials; use non-flammable recovery wadding.
6. To prevent accidental eye injury, always place the launcher so the end of the rod is above eye level, or cap the end of the rod with the hand when approaching it.

7. Never place head or body over the launching rod. When the launcher is not in use, always store it so that the launch rod is not in an upright position.
8. Do not let anyone approach a model rocket on a launcher until making sure that either the safety interlock key has been removed or the battery has been disconnected from the launcher.
9. Do not launch a rocket so its flight path will carry it against a target on the ground; never use an explosive warhead nor a payload that is intended to be flammable. The launching device must always be pointed within 30 degrees of vertical.
10. The system used to launch model rockets must be remotely controlled and electrically operated, and must contain a switch that will return to "off" when released. All persons should remain at least 10 feet from any rocket that is being launched.

PHY 9.3 Recovery

1. Never attempt to recover a rocket from a power line or other dangerous places.
2. Always use a rocket system with model rockets that will return them safely to the ground so that they may be flown again.

PHY 10: Chemical Safety in the Physics Laboratory

All teachers should be familiar with the RCSS Chemical Management policy that addresses how chemicals should be properly stored, labeled, and secured, as well as who should have access to these chemicals and chemical storage locations. The following guidelines are provided for teachers in order to reduce the risk of chemical accidents and ensure that chemicals and products in their schools are stored and handled safely.

PHY 10.1 Specific Chemical Hazards Associated with Physics

PHY 10.1.1 Carbon Dioxide

The use of dry ice in cryogenic experiments must be accompanied by precautions against production of an oxygen-deficient atmosphere. Carbon dioxide, which is denser than air, easily collects in a non-ventilated area.

PHY 10.1.2 Carbon Monoxide

Do not allow carbon monoxide from incomplete combustion to collect in a closed area. Always conduct demonstrations using small internal combustion engines under a vented hood or outdoors.

PHY 10.1.3 Explosives

1. Making explosive compounds such as those that might be used in model rocketry is forbidden in RCSS labs.
2. Only factory-made, pre-loaded rocket engines should be used for this purpose.

PHY 10.1.4 Mercury and Other Heavy Metals

1. The use of free mercury, lead, cadmium, or other heavy metals is forbidden in RCSS laboratories.
2. The use of equipment containing mercury, lead, cadmium, or other heavy metals is forbidden in RCSS laboratories.
3. The use of lead, cadmium, or other heavy metal based solder is forbidden in RCSS laboratories.

PHY 10.2 Flammable Materials

PHY 10.2.1 Safety Concerns

1. Do not use flammable substances near an open flame unless the purpose is to demonstrate flammability.
2. Many flammables produce toxic fumes and should be burned only under a vented hood.
3. Large containers of flammable liquids should be opened, and liquids transferred, in a room free from open flames or electrical arcs and, preferably, under a fume hood.

PHY 10.2.2 Storage

Guidelines for flammable storage must follow **O.C.G.A. 25-2, O.C.G.A. 45-22-2, OSHA Standard 29 CFR 1910**, and **NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals** and **NFPA 30: Flammable and Combustible Liquids Code.**

All cabinets for storage of flammable materials must be in compliance with statutes, regulations and local ordinances promulgated pursuant to **O.C.G.A. Title 25, Chapter 2, OSHA Standard 29 CFR 1910, and NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals**. In addition, all flameproof cabinets must meet the design and installation criteria set forth in the **NFPA's latest version of NFPA 30: Flammable and Combustible Liquids Code.**

1. The maximum allowable quantity for flammable liquid storage in any size lab is not to exceed 480 liters.
2. Regarding flammable liquid storage outside of approved flammable storage cabinets: there may be a maximum of 40 liters of flammable liquids in original containers and an additional 100 liters in approved safety cans not to exceed 8 liter size (**NFPA 45**).
3. NFPA specified safety cabinets MUST be used for storage of flammable liquids.
4. High schools should not be in possession of any flammable liquid that requires storage in explosion-proof refrigerators and/or freezers.
5. All flammables must be stored by compatibility.

PHY 10.3 Procurement of Chemicals

1. Prior to ordering, determine whether the chemical is in stock.
2. Order only quantities that are necessary for the project. Remember: "**Less is better**".
3. Upon receipt of the chemical, make sure the date received and the owner's initials are on the label.

PHY 10.4 Labeling of Chemical Containers

No unlabeled substance should be present in the laboratory at any time!

1. Use labels with good adhesive.
2. Use a permanent marker (waterproof and fade resistant) or laser (not inkjet) printer.
3. Print clearly and visibly.
4. Replace damaged, faded, or semi-attached labels.

PHY 10.4.1 Commercially Packaged Chemicals

1. Verify that the label contains the following information:
    a. Chemical name (as it appears on the MSDS)
    b. Name of chemical manufacturer
    c. Necessary handling and hazard information
2. Add:
    a. Date received
    b. Date first opened
    c. Expiration or ―use by date (if one is not present)

PHY 10.4.2 Secondary Containers and Prepared Solutions

1. When a material is transferred from the original manufacturer's container to other vessels, these vessels are referred to as ―secondary containers.
2. Label all containers used for storage with the following:
    a. Chemical name (as it appears on the MSDS)
    b. Name of the chemical manufacturer or person who prepared the solution
    c. Necessary handling and hazard information
    d. Concentration or purity

e. Date prepared

f. Expiration or —use by date

PHY 10.4.3 Containers in Immediate Use

1. These chemicals are to be used within a work shift or laboratory session.
2. Label all containers in immediate use with the following:
3. Chemical name (as it appears on the MSDS)
4. Necessary handling and hazard information

PHY 10.4.4 Chemical Waste

All containers used for chemical waste should be labeled with the following:

1. HAZARDOUS WASTE
2. Chemical name (as it appears on the MSDS)
3. Accumulation start date
4. Hazard(s) associated with the chemical waste
5. Date generated

Complete the Waste Disposal Form for removal of all waste (chemicals and broken glass) at the end of each semester. The Science/STEM Coordinator (Dr. Chaundra Creekmur; creekch@boe.richmond.k12.ga.us) will facilitate removal.

PHY 10.5 Material Safety Data Sheets (MSDS)

1. There must be an MSDS on file for every chemical compound in use in the lab.
2. At a minimum, MSDS information should be located in all chemical storage rooms and cabinets and in a central place within the school (away from the chemicals), as well as a central location for the school district.
3. A copy must be kept in an area that is accessible to all individuals during periods of building operations.
4. If no MSDS is available for a product because 1) the manufacturer no longer exists; or 2) the manufacturer cannot be identified from the label that material should be considered hazardous waste and disposed of in a manner consistent with federal and state regulations.

PHY 10.6 Proper Chemical Storage

Guidelines for chemical storage must follow **O.C.G.A 45-22-2, O.C.G.A. 25-2, OSHA Standard 29 CFR 1910, and NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals** and **NFPA 30: Flammable and Combustible Liquids Code.**

1. Hazardous chemicals in schools should be stored in accordance with MSDS specifications
2. Chemicals should not be stored in areas that are occupied by or accessible to students, such as classrooms or restrooms; they should preferably be stored in a central, secure location.
3. Organize chemicals first by **COMPATIBILITY**—not alphabetic succession (refer to section entitled Shelf Storage Pattern). Store alphabetically within compatible groups.

PHY 10.7 Chemical Waste

According to EPA regulations, the following four characteristics define a waste as hazardous:

- Ignitability
- Corrosiveness
- Reactivity
- Toxicity

Management and disposal of laboratory waste in containers are regulated under RCRA regulations. These laboratory waste streams include used chemicals, residues from experiments, spill cleanup, expired or off-spec chemicals and other chemical waste. It is the school's responsibility to make a hazardous waste determination. This includes spent chemicals used in the lab, expired or unwanted chemicals, contaminated gloves, and any spill cleanup debris. Schools must ensure that a RCRA hazardous waste is safely accumulated and transported off-site for proper disposal. Depending on the quantity of waste generated by a school, additional requirements for storage, handling and emergency response may apply.

Depending on the quantity of waste generated by a school, additional requirements for storage, handling and emergency response may apply.

PHY 10.7.1 Proper Storage and Disposal of Chemical Waste

The following guidelines are provided to schools and administrators and should be used for storing and disposing of hazardous waste:

PHY 10.7.1.1 Segregation and Storage of Waste

1. Separate waste containers are required to properly segregate waste for disposal. The following waste categories should be used.
    - Nitric Acid
    - Hydrofluoric Acid
    - Hexavalent Chrome
    - Cyanides
    - Oxidizers
    - Reducing Agents
- Sulfides
- Palladium
- High pH Alkaline Solutions
- Low pH Acidic Solutions
- Non-Chlorinated Solvents
- Chlorinated Solvents

2. Chemicals that are stored for disposal off-site should be placed in suitable closed containers and should be clearly marked with the contents. If the chemicals are a RCRA hazardous waste, the school must ensure that they are transported offsite for proper disposal.
3. Store all waste in containers that are in good condition and are compatible with their contents. Avoid using metal containers; certain chemicals can cause the metal to corrode and the container to leak.
4. Clearly and permanently label each container as to its contents and label as hazardous waste.
5. Store waste in a designated area away from normal laboratory operations and to prevent unauthorized access. Store waste bottles away from sinks and floor drains.
6. Do not completely fill waste bottles; leave several inches of space at the top of each waste container. Securely cap all waste bottles.

PHY 10.7.1.2 Disposal of Hazardous Waste

1. **THE USE OF SINKS FOR THE DISPOSAL OF CHEMICALS IS STRICTLY PROHIBITED!**
    a. When rinsing glassware that contained chemical, discard the first rinse volume into the appropriate waste container.
    b. Subsequent rinses can be discarded to the sink.
2. Water/air reactive wastes are restricted by waste disposal companies and must be deactivated prior to disposal.
    a. This is particularly true of materials which ignite or release gases on contact with air or water.
3. Dispose of chemically contaminated paper and disposable clothing in approved solid waste containers.
4. Do not treat hazardous waste on-site. Exception: Acids may be neutralized with sodium bicarbonate in a 50-50 ratio by weight.

5. Contact Facilities and Maintenance for pick-up and disposal. Document when pick-up was requested and when pick-up occurred.

Complete the Waste Disposal Form for removal of all waste (chemicals and broken glass) at the end of each semester. The Science/STEM Coordinator (Dr. Chaundra Creekmur; creekch@boe.richmond.k12.ga.us) will facilitate removal.

PHY 10.7.1.3 Record Keeping

1. Reassigned samples must be re-labeled with the new custodian's name and the date the waste was generated and stored.
2. A waste management log must be maintained and should indicate how and when the waste was generated, how and when it was isolated and stored, by whom it was generated and stored, and date and method in which it was disposed.

PHY 11: Fire Hazards

Fire is a real danger in any laboratory setting, and all teachers need to be aware of how to prevent fires. In the vent a fire does occur, teachers need to know how to respond appropriately. The following information is provided as guidance in preventing or combatting fires in the science laboratory.

PHY 11.1 Preventing Burns and Fires

PHY 11.1.1 When planning to heat materials or use open flames

1. Instruct students on STOP DROP AND ROLL in the event clothing catches fire.
2. Make sure students know how to evacuate the classroom in the event of a large fire.
3. Know the location of the nearest fire extinguisher and know how to use it.
4. Have a bucket of sand or a fire blanket nearby in the event that the nearest fire extinguisher too far outside of the classroom.

PHY 11.1.2 When heating materials

1. **DO NOT USE ALCOHOL BURNERS! T**hey are extremely hazardous. Safer alternatives to alcohol burners include candles and hot plates.
2. **DO NOT USE STERNO HEATERS!**
3. Make sure that the area surrounding a heat source is clean and has no combustible materials nearby.
4. Do not allow students to work with hot materials, such as very hot water.
5. Do not use household glass. Use only borosilicate laboratory glassware, such as Kimax™ or Pyrex™ when heating substances.
6. Do not heat common household liquids, such as alcohol or oil; these are flammable and should not be heated. Heat only water or water solutions.
7. Handle all hot materials using the appropriate type of tongs or heat resistant gloves (those made of asbestos or thick silicon rubber).

PHY 11.1.3 When using hot plates

1. Do not use hotplates designed for use in home kitchens. Use only laboratory type hot plates. These are sealed against minor spills.
2. Do not place the hot plate on paper or wooden surfaces.
3. Place the hot plate in a location where a student cannot pull it off the worktop or trip over the power cord.
4. Never leave the room while the hot plate is plugged in, whether or not it is in use.
5. Keep students away from hot plates that are in use or still hot, unless you are right beside the students and have given them specific instructions.
6. Make sure that the hotplate is both unplugged and cool before handling a hotplate. You can check to see if a hot plate is still too hot by placing a few drops of water on the surface. If the water does not evaporate, it should be cool enough to touch.

PHY 11.1.4 When using open flames

1. Use only safety matches. Make sure the matches are stored in a secure place between uses.
2. Closely supervise students when they use matches. Make sure students are dressed properly (baggy clothes are tucked in, long sleeves are rolled up, smocks/aprons are properly tied) and have long hair/braids tied up.
3. Closely supervise students when they use candles. Make sure students are dressed properly (baggy clothes are tucked in, long sleeves are rolled up, smocks/aprons are properly tied) and have long hair/braids tied up.
4. Use tea candles that are short and wide, and cannot be knocked over in normal use.
5. Place all candles in a “drip pan,” such as an aluminum pie plate, that is large enough to contain the candle if it is knocked over.
6. Never leave the room while a flame is lit or other heat source is in use.

PHY 11.1.5 Bunsen Burner Safety Guidelines

Bunsen burners present fire hazards. They produce an open flame and burn at a high temperature, and as a result, there is potential for an accident to occur. For the safety and convenience of everyone working in a laboratory, it is important that the following guidelines be observed.

1. Remove all papers, notebooks, combustible materials and excess chemicals from the area.
2. Tie-back any long hair, dangling jewelry, or loose clothing.
3. Inspect hose for cracks, holes, pinch points or any defect and ensure that the hose fits securely on the gas valve and the burner. Replace all hoses found to have a defect before using.
4. Notify others in the laboratory that the burner will be in use.
5. Have the sparker/lighter available before turning on the gas.
6. Utilize a sparker/lighter with extended nozzle to ignite the burner. Never use a match to ignite a burner.
7. Adjust the flame by turning the collar to regulate air flow and produce an appropriate flame for the experiment (typically a medium blue flame).
8. Do leave the laboratory while the burner is on and do not leave open flames unattended.
9. Shut off gas when its use is complete.
10. Allow the burner to cool before handling. Ensure that the main gas valve is off before leaving the laboratory.

PHY 11.2 In the event of a large, uncontainable fire

1. Evacuate the classroom immediately.
2. Locate and pull the nearest fire alarm.
3. Notify public safety and/or administration about the fire. Make sure you include the location and source (chemical, paper, petroleum) of the fire.

PHY 11.3 In the event of a small, containable fire

1. Identify the type of fire. The table below lists the four classes of fires and methods for extinguishing them:

Class	To Fight Fires Involving	Method to Extinguish
A	wood, paper, cloth	Use water or dry chemical extinguisher.
B	gasoline, alcohol, paint, oil, or other flammable liquids	Smother by using carbon dioxide or dry chemical extinguisher.
C	fires in live electrical equipment	Cut off power to electrical equipment. Use ABC or carbon dioxide fire extinguisher.
D	metals (Na, K, Mg, etc.)	Scoop dry sand onto fire.

2. Use the appropriate method to extinguish the fire.
3. File an incident report.

PHY 11.4 In the event a student's clothes catch fire

1. Roll the child on the floor to smother the fire. Use a fire blanket if one is available. Do not direct a carbon dioxide (CO_2) fire extinguisher at an individual because such extinguishers produce dry ice that can cause frostbite. Periodically check on the location and condition of fire extinguishers.
2. **DO NOT ATTEMPT TO ADMINISTER FIRST AID TO ANY BURNS THE CHILD MAY HAVE SUSTAINED!** Immediately notify the school administrator, school nurse, and public safety.