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| **TEXAS CTE LESSON PLAN**[www.txcte.org](http://www.txcte.org) |
| **Lesson Identification and TEKS Addressed** |
| **Career Cluster** | Law, Public Safety, Corrections, & Security |
| **Course Name** | Forensic Science |
| **Lesson/Unit Title** | Forensic Use of Light |
| **TEKS Student Expectations** | **130.339. (c) Knowledge and Skills**(3) The student uses scientific methods and equipment during laboratory and field investigations.(F) The student is expected to collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micro-pipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, dissection equipment, meter sticks, and models, diagrams, or samples of biological specimens or structures(7) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene.(C) The student is expected to determine the direction of a projectile by examining glass fractures(D) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to define refractive index and explain how it is used in forensic glass analysis(E) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to describe the instrumental analysis of trace evidence such as microscopy and spectrometry |
| **Basic Direct Teach Lesson**(Includes Special Education Modifications/Accommodations and one English Language Proficiency Standards (ELPS) Strategy) |
| **Instructional Objectives** | The student will be able to:1. Describe the electromagnetic spectrum and light characteristics such as waves, wavelength, frequency, and speed.
2. Explain and utilize scientific technology, such as various microscopes, types of lasers, and the spectrophotometer, that apply the properties of light to investigate trace evidence.
3. Determine the identity of trace evidence by applying scientific theories of light such as light refraction, diffraction, dispersion, and the atomic emission spectrum.
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| **Rationale** | Light, mostly white light and ultraviolet, is used to collect evidence at the crime scene. Forensic scientists use equipment/technology and various scientific theories about light to analyze, identify, and match trace evidence. Therefore, comprehending the properties of light is essential to understanding how light is used in the field of forensics. |
| **Duration of Lesson** | 9 ½ hours total* 3 hours lecture
* 1 hour engage
* 4 ½ hours activities
* 1 hour quiz and exam
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| **Word Wall/Key Vocabulary***(ELPS c1a,c,f; c2b; c3a,b,d; c4c; c5b) PDAS II(5)* |  |
| **Materials/Specialized Equipment Needed** | * Forensic Use of Light Fill-in-the-Blank Venn Diagram and Key
* Computers with Internet access
* Projector for student presentations
* Flame Demonstration
* Handout and Key
* Computers with Internet access Basic Use of a Microscope Lab
* Basic Use of a Microscope Lab Handout and Key
* Compound microscope
* Glass or beaker of water
* Variety of prepared slides
* Eyedropper (plastic disposable is OK)
* Electricity Source (possible with power strips)
* Newspaper sections
* Microscope slides and cover slips
* Small scissors
* Tweezers
* Refractive Index (RI) of Fibers Lab Handout
* Fiber Samples of Known Composition
* Glass slides
* Fiber Samples of Unknown Composition
* Cover slips
* Above Refractive Index Fluids
* Compound microscope
* Small beakers for fluids
* Small scissors
* Eyedropper (disposable is OK)
* Tweezers
* Light Diffraction Hair Diameter Lab Handout and Key
* Helium-Neon laser (also called a He-Ne laser)
* Transparent tape
* Scissors
* Index card
* Metric ruler
* Meter stick
* Binder clips
* Pencil
* Marker
* Handheld, 1-hole punch
* White paper taped on wall (legal size) or a screen to project image on Spectrophotometer Use for Soil Analysis Lab
* Spectrophotometer Use for Soil Analysis Lab Handout and Key
* Directions for Using the “Spec 20” Spectrometer
* Spectrophotometer (Spec 20 is an example of one type that could be used in this lab)
* Unscratched cuvettes for the spectrophotometer
* 3 different soil types
* 10ml graduated cylinder
* Timer or watch for one-minute intervals
* Tap water
* RI of Glass by Submersion Lab Handout and Key
* Evidence bags with glass samples
* 5 – 7 test tubes
* Tweezers
* Test tube rack
* Soap
* Test tube brush
* 25ml graduated cylinder
* Samples of different oils: clove, cinnamon, castor, olive, vegetable, and isopropyl alcohol, and water
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| **Anticipatory Set**(May include pre-assessment for prior knowledge) | Do an Internet search for a video using the following: Flame Test 07. Show the students the video and then have them answer the following questions (also found on the Flame Demonstration Handout). After five minutes of reflection on their answers, lead the class in a discussion about the properties of the flames. Use the Flame Demonstration Key and the Discussion Rubric for assessment.* How could this chemical property of compounds/elements be used in forensics?
* What causes the flames to be different colors?
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| **Direct Instruction \*** | 1. Forensic Use of Light – an understanding of light energy, its properties, its uses, and its technological applications is fundamental in the study of forensics
	1. Location/Collection of Evidence with Light – light, and all of its sources, is used to locate evidence
	2. Observation of Evidence with Light – once evidence has been located and collected, light is used to observe it
	3. Analysis of Evidence with Light – science has made many discoveries about light, and these are applied to analyze forensic evidence
2. Wave Theory of Light
	1. Light and Sound Similarities
		1. Light travels in the form of waves, just like sound waves; in fact, many of the properties of light are comparable to sound waves
		2. Our ears hear different sounds because of the different frequencies of sound
		3. Our eyes see color because of the different frequencies of reflected light
		4. Just like there are sounds our ears cannot detect, there are colors of light we cannot see
	2. Light and Sound Differences
		1. Light waves are much faster than sounds waves
		2. Sound waves require a medium to travel through; light waves can travel through a vacuum
	3. Wave Definitions
		1. Wave – when some form of energy (light, sound, water) is transferred by a disturbance in a medium (light waves do not require a medium)
			1. Longitudinal (or compressional) waves – energy is transferred in the same direction the wave is moving (waves that travel like a flexible helical spring toy that somersaults down steps)
				1. Example – sound waves
			2. Transverse waves – energy is transferred perpendicularly in a ripple effect (like ripples in a puddle)
				1. Example – light waves
		2. Wavelength (λ) – the distance from the top of one wave to the top of the next
			1. Larger waves have a longer wavelength
			2. Smaller waves have a shorter wavelength
			3. The unit used for light wavelength is the meter (m)
				1. Although you will see centimeters or even nanometers, these must be converted to meters to do any type of frequency formulas
		3. Wave Speed (c) – different wave mediums travel at different speeds
			1. The speed of light is 3.0 x 1010 cm/s or 3.0 x 108 m/s (speed is considered as though in a vacuum)
			2. The unit of speed of a wave is meters/second, although you will see other units like centimeters/second
		4. Frequency (v) – the number of waves that pass per unit of time; wavelength and frequency are inversely related
			1. Longer wavelength means shorter frequency (the waves are farther apart, so there are less waves per second)
			2. Shorter wavelength means higher frequency (the waves are closer together, so there are more waves per second)
			3. The unit for frequency showing cycles per second is the Hertz (Hz)
			4. Frequency and wave energy are synonymous
		5. Wave Formula
			1. The speed of light is 3.0 x 108 m/s
			2. Symbols
				1. c = speed of the type of wave (can be the speed of light)
				2. λ = wavelength (meters)
				3. v = frequency (Hz)
			3. Wave formula in symbols – c = λν
			4. A variation with the speed of light substituted for (c) – 3.0 x 108 m/s = λν
			5. Wave formula in words – speed equals wavelength times frequency
			6. So, the speed of the wave is a product of frequency and wavelength
		6. Amplitude – the height of the wave from the bottom (trough) to the top (crest)
			1. Amplitude is also thought of as the energy the wave carries
			2. Wavelength, speed, and frequency do not change just because the height (amplitude) of the wave changes
	4. Electromagnetic Spectrum – there is an array of different light waves with characteristic colors, invisibilities, wavelengths, and frequencies. The entire range of known light waves is called the electromagnetic spectrum. Light waves can also be called electromagnetic radiation or “radiation”
		1. Radio waves and microwaves are not visible to the human eye; they have a longer wavelength and smaller frequency. Radios, microwaves, and cell phones use these waves (frequency is how we tune our radios)
		2. Infrared light is invisible to the human eye, but is used in technology/forensics for evidence detection/analysis (i.e. remote controls, lasers, etc.)
		3. Visible Spectrum – the middle of the spectrum is the only part of the spectrum that is detectable by the human eye
		4. Ultraviolet light (black light), also invisible to the human eye, is used to disinfect foods, but it is also used in forensics extensively to detect/analyze evidence
		5. X-rays and gamma rays are invisible to the human eye, and their radiation can penetrate the human cell and cause DNA damage. Some types of X-rays are used in analysis
	5. Visible Spectrum
		1. Light (sunlight/electric light bulb) makes it possible for us to
		2. “see” anything—the light that we use to “see” is called white light
		3. White light is actually a combination of all known colors
		4. Visible light can be any color we see, from red (longer wavelength, smaller frequency) to purple (shorter wavelength, larger frequency)
		5. An object absorbs most of the visible wavelengths and reflects some of the wavelengths – this is what we see as color
		6. Examples
			1. Green color – plants absorb all wavelengths (colors) to use as energy, but reflect the light wavelength we see as the color green
			2. Blue jeans – jeans absorb all wavelengths, but reflect the light wavelength we see as the color blue
			3. White object – the object absorbs no wavelengths, and reflects all of them, so we see the color white (this is why the color white seems cooler to wear in the summer)
			4. Black object – the object absorbs all wavelengths, and reflects none of them, so we do not see any color (this is why the color black is so hot to wear in the summer)
		7. Any object will absorb and reflect different light wavelengths depending on its composition (more in this in the particle unit)
			1. The chemical compounds the object is made of
			2. Or the chemical compounds of the paint on the object
	6. Forensic Use of the Electromagnetic Spectrum
		1. Investigators should use all forms of light possible when gathering evidence
			1. Regular white light to detect as many items as possible (but it may not reveal all of the evidence that is present)
			2. Ultraviolet (UV) light to detect those items which will reflect invisible, shorter wavelength light (such objects will fluoresce with UV light)
			3. Infrared (IR) light to detect those items which will reflect invisible, longer wavelength light
		2. A good forensic light source is made up of a powerful lamp containing all of the light wavelengths including the ultraviolet, visible, and infrared components of light
3. Particle Theory of Light – light (electromagnetic spectrum) behaves like a wave in the way it travels; however, light also acts like a particle in the way it transfers energy to electrons (this is called the Dual-Theory of Light)
	1. Photon – an energized packet of light energy
		1. In the late 1800’s/early 1900’s, scientists started to notice that not only did light behave like a wave, sometimes it seemed like there were particles of light
		2. This idea of particles was combined with the Atomic Theory to create new light theories (Quantum Physics)
		3. Photons of light are absorbed (energy gained) and emitted (light is given off)
	2. Atomic structure review
		1. Every atom has a nucleus in the middle surrounded by electrons at different orbitals, or “energy levels”; you can think of it like the sun (nucleus) with the planets (electrons)
		2. These electrons are circling, or “orbiting,” the nucleus
		3. These orbits are in paths farther and farther away from the nucleus
		4. The farther an orbital is from the nucleus, the more energy the electrons in that orbital have (or the “higher” the energy levels
		5. Every element’s atoms are different in their available orbitals or energy levels
		6. Electrons also vibrate at specific frequencies; the frequencies of the vibrations are related to the energy level of the electrons
	3. Quantum physics
		1. Photons move at different frequencies depending on the frequency of the electromagnetic wave
		2. Light intensity means there are more photons moving, but the photon frequency (energy level) stays the same
		3. Light intensity fades over distances because the photons scatter farther and farther apart
		4. If a photon is moving at the same frequency as the electron then the electron “absorbs” the photon’s energy; the photon’s energy has now become heat energy
		5. If the photon is moving at a different frequency than the electron, all the electrons’ vibrations are disrupted; this disruption causes one of the electrons to become “excited” enough that it will move up an energy level, so it is farther from the nucleus (the exact energy level reached is different for each specific element)
		6. An energized electron stays at this new energy level briefly before it drops down to its original level; the time period between jump and drop differs between elements (phosphorescent elements’ electrons stay at the new energy level for a longer period and then drop later)
		7. This drop from a higher orbital to a lower orbital causes the electron to transfer its energy to a photon at a specific frequency
		8. We see the photon’s energy emitted as light. Different elements have their own specific orbitals (energy levels), so they release an assortment of frequencies of light
		9. Humans can see this light energy released in the form of distinctive colors with particular wavelengths and/or frequencies, depending on each individual element
		10. Atomic Emission Spectra – this is a spectrum of emissions from individual elements and it is used to identify unknown elements
4. Categories of Light Reactions in Forensics
	1. Two Sources of Light – in general, “light” refers to the portion of the electromagnetic spectrum that we see; energy (except that from heat) that causes an object to release light is a form of electromagnetic radiation that we cannot see
		1. Incandescence
			1. The term for light that is produced by something that gets very hot (heat energy excites the photons)
			2. Example – a fire or the filament in a light bulb
		2. Luminescence
			1. A general term for “cold” light that is not produced by heat, but another form of energy (or electromagnetic radiation) that excites the photons
			2. Example – fluorescent lights
		3. Types of Luminescence – classified by the energy that creates the luminescence (not all examples are shown below)
			1. Chemiluminescence
				1. Luminescence that results from energy released during a chemical reaction
				2. Example – glow sticks, luminol spray reacting with blood
			2. Thermo-luminescence – luminescence in minerals or crystals stimulated by the application of heat energy to temperatures below those needed for incandescence
			3. Photoluminescence
				1. Light is absorbed and then re-emitted at a less energetic wavelength
				2. Phosphors are any substance that exhibits this
				3. Two Types of Photoluminescence that Absorb Ultraviolet Energy

FluorescenceInvolves absorbing short wave energy and remits long wave energy almost immediatelyAny object seen under ultraviolet light (black light); objects appear to glowPhosphorescenceAbsorbs both low heat energy and other electromagnetic energy, but has a delayed light releaseElectrons do not immediately drop to their original energy level, but drop later so long wave energy (colored light) continues even after the radiation ceases—in the dark* 1. Phosphors – any substance that causes an object to show photoluminescence
		1. So, when an object glows in the dark, or lights up under UV radiation, it is because it contains phosphors
		2. Many different types of phosphors are found in many locations
			1. Rare earth minerals on the Periodic Table (especially the Lanthanides)
			2. Many transition metals on the Periodic Table
			3. Nucleic acids found in DNA
			4. Biomolecules – found in the human body, especially in bodily fluids
		3. Phosphors have many uses including radar detection and plasma screen TV’s
		4. In forensics, investigators and scientists take advantage of the fact that there are many different types of phosphors found in the human body and other types of forensic evidence; this makes the use of UV lights irreplaceable in evidence collection
1. Review of Particle Data for the Properties of Light
	1. Every element will pick up its specific frequency or frequencies from a photon, thus every element’s electrons jump to its individual energy levels
	2. When the electron drops back to the original level, it emits a characteristic frequency or frequencies of photons; this is seen as a particular color for each element
		1. An energy source will cause a compound or object to release a distinctive emission of light depending on its components (this is why the flame test in Chemistry is used to ID elements)
		2. This characteristic can be used in forensics to identify unknown compounds or the elements in a compound
		3. Since different substances will absorb and reflect only specific wave frequencies, a variety of wave frequencies (light sources) should be used to collect and analyze evidence
2. Light Properties – light has many different behaviors; again, some are like waves and others are similar to particles
	1. Main Types of Light Properties
		1. Emission – the production of light from a compound due to the particle nature of light causing an increase in the electron’s jumping energy levels (emission of light color is specific to the composition); remember the Atomic Emission Spectrum
		2. Absorption – light energy (photon energy) is taken in because the frequency of the light wave (photon) matches the frequency at which the electrons in the atom vibrate (absorption of light is specific to composition)
			1. Energy from electromagnetic radiation becomes heat energy
			2. The object is considered opaque – no light travels through it (light is either absorbed or reflected)
			3. There is also an atomic absorption spectrum individual to each element
		3. Transmission – the vibrations of the electrons are passed on to neighboring atoms through the bulk of the material and will be reemitted as photons on the opposite side of the object
			1. Electron and photon vibrations are not exactly the same frequency, but electrons are not energized enough to move to the next energy level
			2. The object is considered transparent – all light travels through it (light is neither absorbed nor reflected)
			3. Light travels through at the same speed, there is no refraction (bending)
		4. Reflection – light energy causes a disruption because the frequency of the light wave does not match the electron’s vibration frequency; another photon is released
			1. If light waves are reflected off of the surface, we see the object and its color (mirrors and chrome reflect almost all of the light waves)
			2. The object is considered opaque – light does not travel through it
			3. The angle of the light wave changes, but wavelength, wave speed, and wave frequency all stay the same
			4. Reflection Rule – the angle of incidence equals the angle of reflection
			5. Angle of Incidence – the angle of the light that strikes a surface
			6. Angle of Reflection – the angle that the light is reflected, or bounces off of the surface
			7. We are changing the angles when we adjust our rearview mirrors
			8. In forensics, the properties of the reflection are being utilized whenever any kind of light is used for finding, observing, or analyzing evidence
		5. Refraction – the vibrating photon has the same frequency as the vibrating electron, but there is a time delay between the jump and the drop of the electron
			1. This time delay causes both the speed of the wave and the wavelength to change, but the frequency remains the same
			2. Light (or the object) seems to bend – the wave speed changes because the light is traveling through two media with different densities; since light travels through the medium, the medium is considered transparent
			3. Example – when you look through the side of a clear glass of water with a spoon in it, it appears that the spoon bends as it enters the water (two media of different densities: air and water)
			4. The light wave bends because the direction of the light wave changes
			5. The light wave direction changes because the wave speed and the wavelength both change
			6. Frequency
				1. Does not change in refraction, so the color does not change
				2. The wave formula explains this: speed = wavelength x frequency (even though the speed and wavelength change, the frequency does not
			7. Refractory Index (RI) – every transparent object has a different refractory index, this is defined mathematically (Snell’s Law)
				1. Can be defined by comparing angles or wave speeds
				2. The temperature and frequency of the wave must be controlled because changes in these will affect the refractory index
				3. Angular Refractive Index (RI) – a mathematical comparison of the angle of incidence and the angle of refraction (RI = sin i  sin r) Angle of incidence (i) – the angle that light strikes the medium’s surface
				4. Speed Refractive Index (RI) – a mathematical comparison of the speed of light in a vacuum and the speed of light in the medium (substance) (RI = speed of light in a vacuum  speed of light in the medium)
			8. Many materials and fluids have a known refractive index (in forensics, an unknown substance can be compared to the refractive index of a known substance, such as glass)
			9. Different lenses also use the properties of refraction
				1. Convex Lenses – use the power of refraction to bend the light so that it makes an object appear larger and easier to observe
				2. Concave Lenses –use the reverse power of refraction in cameras to make large objects small enough to photograph; several lenses and their movement can be used in microscopes and the like to bring objects into focus
			10. Birefringence – an object that has bends waves in more than one direction (has several refractive indexes)
		6. Dispersion (a type of refraction) – when white light passes through certain media the light is refracted according to its wavelength
			1. Example – a prism breaks white light into all its wavelengths, and a rainbow of colors appears
			2. Different transparent objects have different dispersion levels
			3. The properties of dispersion are used in spectrophotometers to break apart the emission/absorption waves of certain substances for identity purposes
		7. Intensity – this is a combination of the energy and height of the wave (amplitude)
			1. We see it as the brightness of light, not a change in color
			2. The intensity of light decreases with the distance traveled
		8. Diffraction – a change in the direction of waves as they pass around an opening or around an obstacle in their path (diffraction is a form of interference)
			1. A light wave might appear to bend around a corner
			2. Example – water waves hitting a pier
			3. There is no change in wave speed, frequency, or wavelength (just direction)
			4. Light waves might appear to spread out after they travel through a small opening
		9. Interference – when two light waves coincide, it can be either constructive or destructive (diffusion can be considered a type of interference)
			1. Constructive Interference – the troughs and crests of two waves match up and the amplitude of the resulting wave increases
			2. Destructive Interference – the crest of one wave passes through, or is superimposed upon, the trough of an opposing wave so the amplitude of the wave decreases.
		10. Polarization – the separation of different directions of light waves (a filter clarifies images due to this separation/block of specific waves)
			1. Colored lenses filter certain frequencies used in forensics to collect and observe evidence
			2. Lenses are also used in photography to clarify images
			3. Sunglasses and sunscreens block UV rays
3. Light Properties Are Used in Forensics – technology has advanced significantly in its use of light; all the properties and behaviors of light are used for multiple purposes, including criminal investigations; light’s properties are used in forensics to find, observe, and analyze evidence
	1. Magnification Purposes – use the properties of refraction (lenses) to detect and observe evidence (sometimes to analyze)
		1. Macro-View (magnifiers and stereomicroscopes) – usually use one convex lens and the properties of refraction
			1. Magnifying Glass – help to detect trace evidence
			2. Stereomicroscope – brings things closer so more details can be seen in a larger scale
			3. Simple Microscopes –early microscopes that are no longer used
		2. Micro-View (compound microscope) – use more than one convex lens and properties of refraction
			1. A fundamental tool in the forensic laboratory
			2. A fast, affordable way to identify/compare trace evidence
			3. Used for both closer observation of the invisible and analysis of evidence
			4. Create luminescence lighting and refract the light with convex and concave lens
			5. Objectives show the powers of magnification created by the various lenses
		3. Types and Techniques of Microscopy
			1. Bright Field Microscope – a basic classroom microscope that aims light toward a lens below the specimen stage
			2. Dark Field Microscope – converts a bright field microscope by using an opaque disk under a condenser lens to scatter light from the specimen; light comes from the particles on the side of the specimen, through the eyepiece, to the eye
			3. Phase Contrast – uses a phase plate to slightly increase the wavelength so that it can use light interference rather than light absorption/reflection; this allows for the imaging of transparent samples by making them appear darker
			4. Differential Interference Contrast (DIC) or Nomarski Microscopes – use light interference rather than absorption or reflection of light to give specimens a three-dimensional appearance; use a polarizer, prism, and condenser to change the light vibration plane, and then separate and recondense light (used for biological specimens)
			5. Polarized Light Microscope – use polarized filters or lenses and/or a rotating stage to show different refractive indexes of evidence in color for samples whose optical properties can vary with orientation or which have birefringence (used with fiber-, soil-, mineral-type samples)
			6. Fluorescence – uses only a small set of shorter light wavelengths that are then reflected back as longer light wavelengths by phosphors found in the sample to aid in analysis
			7. Infrared/Ultraviolet Light – different wavelengths of light show different characteristics of samples
			8. Digital Microscopes – many microscopes are also combined with cameras using adapters (still and video) to capture enlarged images
			9. Electron Microscopes – do not use light, but a beam of electrons to magnify atomic-size particles; the types of electron microscopes are transmission or scanning electron microscopes
			10. Other Microscopes – there are also inverted, comparison, high and low powered, oil and water immersion, and many other variations that differ in lens, stage, use, etc.
		4. Microscopic Refractive Index – comparison of the refractive index of smaller pieces of evidence when observed under a microscope
			1. Refractive Index (RI) – a mathematical comparison of the speed of light in a vacuum and the speed of light in the medium (substance)
			2. Mounting Medium – the fluid or liquid that a sample is immersed in when put on the microscope slide (possibly with a cover slide on top)
			3. Finding RI – when RI needs to be found, a mounting medium with a known RI is used and a microscope observation made
				1. Becke Line – a dark boundary or halo around an object when it is immersed in a liquid of a different refractory index (used mostly microscopically)

If a Becke Line appears outside the object’s edge, the liquid has a higher refractory index than the objectIf a Becke Line appears inside the object’s edge, the liquid has a lower refractory index than the object* + 1. Micro Colorimetry – it is hard to describe the color of any object (fiber, paint chip, etc.) because color is very subjective; everyone interprets the reflection of light waves differently
		2. Chromaticity Diagram – uses an overlay grid to assign colors numerical coordinates which quantifies the colors and makes their description more objective (developed by the International Commission of Illumination)
	1. Types of Spectroscopy – a spectroscope uses prism or diffusion grating to break apart incoming wavelengths; the specific emission/absorption of wavelengths can be used to identify the unknown element in the composition of evidence
		1. Infrared (IR) Spectroscopy – detects/records absorbed wavelengths just outside the visible range of light (longer
			1. The IR spectrum gives the most information out of all spectrophotometers
			2. Used to identify drug types and paint chips, and to test blood or urine samples
			3. Can destroy evidence
		2. Ultraviolet (UV) Spectroscopy – uses shorter wavelengths to investigate UV absorption of biological compounds and drugs in or out of the human body
		3. Reflectance Ultraviolet Spectroscopy (RUVIS) – a technique using optical filters and lenses to detect latent fingerprints on nonporous surfaces
			1. Used without dusting and can be used on evidence that has been previously super-glued
			2. Produces a detailed image that can be photographed
		4. Raman Spectroscopy – uses a laser on the sample and observes patterns of light waves that scatter
			1. Can be used to find substances beneath surfaces
			2. Determines the internal composition of bones and tissues
			3. Gives information that complements IR spectroscopy
			4. Identifies contents of packages and bottles
			5. Valuable because, unlike IR spectroscopy, Raman doesn’t destroy evidence
		5. Microspectroscopy – the microscope combines with a spectroscope for use with minute samples
		6. X-ray Diffraction/Absorption – uses smaller EM radiation (X-rays) and its diffraction (or absorption) of waves to analyze the crystal structure of samples for identification
		7. Atomic Emission/Absorption Spectroscopy – uses visible light to find the types and concentrations of elements in samples
		8. Microwave Spectroscopy – addresses the microwave region of the EM spectrum to obtain information about molecular structure
		9. Types of Spectrometry that Don’t Use Light – there are other types of technology that categorize matter into a spectrum of its components (pure elements or ions) without the use of electromagnetic radiation, using only ionic mass; but since this analysis still shows the spectrum of every physical component in the sample, it is still referred to as spectrometry
			1. Mass Spectrometry (MS) – measures the mass-to-charge ratio of charged particles to determine the ions, molecules, or elements that make up a sample’s composition
			2. Gas Chromatography (GC) – separates compounds into individual ions
			3. GC-MS – when both are used together, the separated ions are analyzed in a spectrum by the mass spectrometer
	2. Other Forensic Uses of EM Radiation – there are a variety of other ways light properties are used in forensics
		1. Nuclear Magnetic Resonance (NMR) – radio waves and magnetic fields are used to penetrate unknowns and collect information from hydrocarbons
			1. Valuable because it is nondestructive – evidence can still be analyzed again later
			2. Can be used to analyze DNA and/or dangerous samples such as explosives
			3. A form of NMR is used to determine time of death by finding brain metabolite levels
				1. Electron Paramagnetic Resonance – uses microwave (not radio) waves for similar purposes
				2. X-ray Fluorescence, Neutron Activation Analysis (with infrared spectra), Inductive Couples Plasma – other examples of the many technological advances that use various forms of the EM spectrum to analyze and identify forensic evidence samples
		2. Immersion Test – a transparent object (glass) is immersed in several liquids with known refractive indexes to compare the refractive indexes
			1. Glass appears to be “invisible” or disappear in liquid that has the same refractive index
			2. If the liquid has a lower or higher refractive index than the glass, the glass can still be seen (with a halo around it)
			3. Examples
				1. Methanol RI: 1.33
				2. Glycerin RI: 1.47
				3. Clove Oil RI: 1.54
				4. Pyrex Glass RI: 1.47 (would disappear in glycerin)
				5. Lead Glass RI: 1.56 (would disappear in clove oil)
		3. Other Large Scale Uses of Refractive Index
			1. Refractometer – determines the refractive index of various solids and liquid
				1. Used to determine the identity of unknowns in forensics
				2. Can be handheld for fieldwork or larger for a laboratory counter
				3. Also used to determine the density of liquids and the concentrations of various components in the liquids (sugar in urine, drugs in the blood, etc.)
		4. Finding the Diameter/Width of a Minute Object – Thomas Young’s Double Split Patterns (interference/ diffraction of light): an experiment that showed that specific light patterns are dependent on the number of slits through which light is shown
			1. Using the known frequency of light and measurements of interference patterns you can determine the actual width of the solid that caused the light to split
			2. To find the diameter or width of an object: d = lL  10S
				1. d = diameter of a minute object in micrometers (µm)
				2. I = wavelength of the light (nm)
				3. L= distance from the light source to the screen (m)
				4. S = the average distance between bands (cm)
		5. Uses of Infrared Light (Thermal Radiation) – many materials are sensitive to thermal or infrared (IR) radiation (IR waves are longer waves in the EM spectrum)
			1. Used in night vision goggles/equipment
			2. Many types of crime scene evidence are located because they will absorb visible light and show IR
			3. IR luminescence is used for many types of document analysis
				1. Illegal Alteration
				2. Erased Writing
				3. IR absorption or glow from different inks
				4. Revelation of charred document contents
				5. Used in conjunction with other technology
		6. Uses of Ultraviolet Light (Black Light)
			1. Mostly used in evidence collection
				1. Many bodily fluids (biomolecules) fluoresce when illuminated by a source of UV light
				2. Detection of crime scene stains such as saliva, semen, vaginal fluids, urine, and perspiration
				3. Many times, latent fingerprints will fluoresce for detection purposes
			2. UV light analysis is recommended as a first choice by the FBI for examining and identifying biological evidence
			3. Also used for authenticating signatures, paintings, and ink stains
			4. Used in the detection of trace evidence and illegal substances
			5. Used to see the light of luminol in order to find blood evidence
		7. Forensic Light Source
			1. A powerful lamp with ultraviolet, visible, and infrared wavelengths of light that has many components to enhance visualization
			2. Direct lighting, such as a strong white light, is very useful to reveal trace evidence
			3. Oblique or parallel lighting will also reveal small particles
			4. Used with all types of magnifiers and microscopes
			5. A multiple color band can penetrate many skin depths to reveal details of a bruise pattern
			6. White light is normally used first, with other wave lengths, chemicals, goggles, polarizers, and colored lenses are used after the initial observation
		8. Cameras use refraction and polarization properties (various lenses, including colored lenses) to capture permanent proof of evidence and its analysis
			1. Used in evidence collection, observation, and analysis to record results
			2. Used with
				1. Spectroscopy
				2. Scanning electron microscopes
				3. Fluoresce of IR or UV radiation
				4. Luminol (to record the chemicaluminescence of a reaction with blood evidence)
1. Forensics, Technology, and Evidence
	1. Location and Collection of Evidence with Light – light, and all of its sources, are used to locate evidence
		1. Examples
			1. Flashlight
			2. Ultraviolet or black light
			3. Light sources with all wavelengths
			4. Colored goggles or filters
			5. Many types of digital photography
	2. Observation of Evidence with Light – once evidence has been located and collected, light is used to observe it
		1. Examples
			1. Magnifying glass
			2. Microscopes (stereomicroscopes, polarizing microscopes, etc.)
	3. Analysis of Evidence with Light – science has made many discoveries about light, and these are applied to analyze forensic evidence
		1. Some Examples
			1. Microscopes of all types, including electron and ion microscopes
			2. Spectroscopes – used to identify trace evidence
				1. Emission spectroscopy
				2. Gas and mass spectroscopy
				3. Infrared and ultraviolet applications
				4. Microwave, X-Ray, and nuclear forms also
		2. Mass Spectrometry – identification purposes
			1. Gas and liquid chromatography specializations

*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:** NONE
 |
| **Guided Practice \*** | *Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:** NONE
 |
| **Independent Practice/Laboratory Experience/Differentiated Activities \*** | 1. Basic Use of a Microscope Lab. Have students review how to use a microscope by completing the Basic Use of a Microscope Lab Handout.
2. Refractive Index (RI) of Fibers Lab. Have students analyze and compare the RI of fibers by completing the Refractive Index (RI) of Fibers Lab Handout. Use the Individual Work Rubric for assessment. *(Note: if you cannot find fiber samples in the science catalogs or cannot spare the expense, craft stores are a decent source of fibers. Any store that carries fabric will sell remnants at a reduced rate. Match the remnants to a fabric being sold on the floor to identify the type of fabric or fiber. Some stores offer free samples. Also, fluids and fiber types can differ from those in the table on the lab handout – simply look up their refractive indexes on the internet.)*
3. Light Diffraction Hair Diameter Lab. Have students measure the diameter of a hair or fiber by completing the Light Diffraction Hair Diameter Lab Handout. The Light Diffraction Hair Diameter Lab Key has a sample answer that will aid assessment. The Individual Work Rubric may be used as well.
4. Spectrophotometer Use for Soil Analysis Lab. Have students analyze soils by completing the Spectrophotometer Use for Soil Analysis Lab Handout. See the Spectrophotometer Use for Soil Analysis Lab Key and the Directions for Using the “Spec 20” Spectrometer for more details. Use the Spectrophotometer Use for Soil Analysis Lab Key and the Individual Work Rubric for assessment.
5. RI of Glass by Submersion Lab. Have students determine the refractive index of glass through submersion by completing this lab. Use the RI of Glass by Submersion Lab Handout for the activity and the RI of Glass by Submersion Lab Key for preparation and assessment.

*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:** NONE
 |
| **Lesson Closure** |  |
| **Summative/End of Lesson Assessment \***  | * Forensic Use of Light Exam and Key
* Forensic Use of Light Technology Quiz and Key
* Flame Demonstration Handout Key
* Basic Use of a Microscope Lab Key
* Light Diffraction Hair Diameter Lab Key
* Spectrophotometer Use for Soil Analysis Lab Key
* RI of Glass by Submersion Lab Handout Key
* Forensic Use of Light Fill-in-the-Blank Venn Diagram Key
* Discussion Rubric
* Individual Work Rubric
* Research Rubric

*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **References/Resources/****Teacher Preparation** | * Saferstein, Richard. Forensic Science: An Introduction. New Jersey: Pearson Prentice Hall, 2008.
* Bertino, Anthony J. Forensic Science: Fundamentals & Investigations. Mason, OH: South-Western Cengage Learning, 2009
* Deslich, Barbara; Funkhouse, John. Forensic Science for High School Dubuque, Iowa: Kendall/Hunt Publishing Company, 2006
* Texas Education Agency, Forensic Certification Training, Sam Houston State University
* Do an Internet search for a video using the following: Flame Test 07.
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| **Additional Required Components** |
| **English Language Proficiency Standards (ELPS) Strategies** |  |
| **College and Career Readiness Connection[[1]](#footnote-1)** | Science StandardsVIII. PhysicsG. Oscillations and waves* 1. Understand the difference between transverse and longitudinal waves.
	2. Understand wave terminology: wavelength, period, frequency, and amplitude.

J. Optics* 1. Know the electromagnetic spectrum.
	2. Understand the wave/particle duality of light.

Understand concepts of geometric optics |
| **Recommended Strategies** |
| **Reading Strategies** |  |
| **Quotes** |  |
| **Multimedia/Visual Strategy****Presentation Slides + One Additional Technology Connection** |  |
| **Graphic Organizers/Handout** |  |
| **Writing Strategies****Journal Entries + 1 Additional Writing Strategy** |  |
| **Communication****90 Second Speech Topics** |  |
| **Other Essential Lesson Components** |
| **Enrichment Activity**(e.g., homework assignment) | For reinforcement, students will use a Venn diagram to compare and contrast the wave and particle theory of light. Use the Forensic Use of Light Fill-in-the-Blank Venn Diagram for the activity and the Forensic Use of Light Fill-in-the-Blank Venn Diagram Key for assessment.For enrichment, students will research and report on one of the following options:* The many types of spectrophotometers and the ways they are used in analyzing a variety of Forensic evidence
* Quantum theory and its applications in current scientific technology. Use the Research Rubric for assessment.
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| **Family/Community Connection** |  |
| **CTSO connection(s)** | SkillsUSA |
| **Service Learning Projects** |  |
| **Lesson Notes** |  |

1. Visit the Texas College and Career Readiness Standards at <http://www.thecb.state.tx.us/collegereadiness/CRS.pdf>, Texas Higher Education Coordinating Board (THECB), 2009. [↑](#footnote-ref-1)