Sudan University of Science and Technology

College of Graduate Studies

Calibration and Measurement the Spectral Rang of Laser Goggles

معايرة وقياس المدي الطيفي لنظارات الحماية من الليزر

A thesis Submitted for Partial Fulfilment for Requirements of Master Degree in Laser Application in Physics

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الآيـة

قال تعالي:

{ فَمَنِ اتَّبَعَ هُدَايَ فَلا يَضِلُّ وَلا يَشْقَى * وَمَنْ أَعْرَضَ عَنْ ذِكْرِي فَإِنَّ لَهُ مَعِيشَةً ضَنْكاً }
(طـه ١٢٣ ــ ١٢٤)

Dedication

To My Family

To My Teachers

To My Friends

Acknowledgment

First of all, I would like to thanks Allah for giving me the strength to finish this study.

I would like to expressly deepest gratitude to my supervisor **Dr.Ali Abdel Rahman Saeed Marouf** for his encouragement, support and supervision of this study.

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Abstract

Appropriate eye protection is a prerequisite for the safe operation In industrial and laboratory environments. In this thesis some laser goggles in the clinic of the laser institute of Sudan university of Science and Technology and laser lab of Elneelain University were calibrated and measurement of the absorption spectra of laser goggles. The measurements done used Uv-vis spectrometer then the Absorption spectra of each laser goggles were carried out and the spectral range of each laser glasses were specified then it matched with its suitable laser.

مستخلص

استخدام نظارات الحماية للعين مهمة في التطبيقات الصناعية والمختبرية في هذا البحث تمت معايرة بعض نظارات الحماية الموجودة في عيادة معهد الليزر جامعة السودان للعلوم والتكنولوجيا ومختبر الليزر بجامعة النيلين وتم قياس طيف الامتصاصية باستخدام مطياف الاشعة فوق البنفسجية-المرئية ثم تم أخذ طيف الأمتصاص لكل نظارة ومن خلال طيف الأمتصاصية تمت مجانسة كل نظارة مع المنظومة الليزرية الملائمة لها.

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CHAPTER ONE
Introduction and Literature Review
1-Introduction:

Every measuring instrument is subject to ageing as a result of mechanical, chemical or thermal stress and thus delivers measured values that change over time. This cannot be prevented, but it can be detected in good time by calibration.

In the process of calibration, the displayed value of the measuring instrument is compared with the measuring result of a different measuring device which is known to function correctly and accurately and which itself has been made to coincide directly or indirectly with a national (or international) reference instrument.

Due to limitations of standard metrology techniques, the measured spectral characteristics of filters are frequently not determined accurately, especially when there are steep and deep edges. The actual blocking provided by an optical filter is determined not only by its designed spectrum, but also by physical imperfections of the filter, such as pinholes generated during the filter coating process, dirt and other surface defects, or flaws in the filter mounting. Generally commercially available spectrophotometers are used to measure the transmission and optical density spectral performance of optical filters.

Laser goggles play an important role to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation and the individual to other hazards associated with laser devices during operation and maintenance.

Therefore, the ability of filters to selectively transmit desired wavelengths of light while blocking unwanted light is critical. The performance of such filters is determined by their spectral characteristics, including transmission efficiency of the signal and attenuation (or blocking) of the illumination light and undesirable emission wavelengths. In particular, often it is critical for filters to transition from
deep blocking to high transmission over a very short wavelength range

1-2 Literatures Review:

Z. M. Zhang, T. R. Gentile, A. L. Migdall, and R. U. Datla in 1997 they had developed a facility for measuring the transmittance of optical filters at a wavelength of 1064 nm, using a Nd: YAG laser, a power stabilizer, and linear photodiode detectors. A direct measurement method was used for filters with optical densities ~OD's! Less than or equal to 4, and a reference substitution technique was used for filters with OD's as great as 10. The apparatus and data-acquisition system are described. Measurement results for a set of filters are presented. The expanded uncertainties for the measured OD and deduced absorption coefficient are determined through a detailed analysis of all the uncertainty components.

Miklós Lenner, Andreas Fiedler and Christian Spielmann in 2004 they measurement the transmission of ion-doped phosphate glass filters for pulses having a center wavelength of 800nm, aduration of 10fs to 1.2 ps and a fluence range of 0.01 to 30J/cm^2. The measurements suggest, that the filter material preserves its protective features over the whole range. Saturation of absorption was only observed in the picosecond pulse duration range. Transmission of ion-doped phosphate-glass filters used for laser protective eye wear has been investigated for pulses ranging from 10fs to 1.2ps and fluences of 0.01 to 30J/cm2 at 800nm; nonlinear absorption reduces the transmitted energy, enhancing the protective properties. Only for fluences far above the damage threshold they have observed an increased transmission due to self-phase modulation. Their measurements suggest that the filter material used for protective eye wear keeps its protective properties for sub-ps pulses without essential degradation and the presented results are directly utilizable in the design of laser protective eye wear for the femtosecond regime.

Qian Wang, Gerald Farrell, and Thomas Freir in 2005 the ratiometric wavelength-measurement system was modeled and an optimal design of transmission response of the employed edge filter is demonstrated in the context of a limited signal-to-noise ratio of the signal source. The corresponding experimental investigation is presented. The impact of the limited signal-to-noise ratio of the signal source on determining the optimal transmission response of edge filters for a wavelength-measurement by the input signal is split into two equal signals. One passes through a reference beam and the other passes through the edge filter Two photodiodes are placed at the ends of both beams By measuring the ratio of the electrical outputs of the two photodiode.

1-3 Aims of the work:

This work is aims to:

1. Calibrate some laser goggles that used with the laser systems in the lab and the clinic of the laser institute.
2. Determine the accuracy of the laser goggles.
3. Identification of the laser goggles.

1-4 Thesis layout:

This thesis contains four chapters, chapter one contains introduction of research (aims of work, Literatures review), in chapter two theoretical background about laser classification, its hazard , and Laser Safety Filter technology, in Chapter three describe experimental part. Results, discussion, conclusions are in the fourth chapter.

CHAPTER TWO

Basic Concepts of uv-visible spectroscopy

2-1 UV-visible spectroscopy:

Spectroscopy means study of the interaction between matter and radiated energy.and it used to refer to the measurement of radiation intensity as a function of wavelength.

Spectroscopy is basically an experimental subject and is concerned with the absorption, emission or scattering of electromagnetic radiation by atoms or molecules. Electromagnetic radiation covers a wide wavelength range, from radio waves to g-rays, and the atoms or molecules may be in the gas, liquid or solid phase or, of great importance in surface chemistry, adsorbed on a solid surface.

Ultraviolet (UV) and visible radiation comprise only a small part of the electromagnetic spectrum, which includes such other forms of radiation as radio, infrared (IR), cosmic, and X rays.

The energy associated with electromagnetic radiation is defined by the following equation:

$$E=hv$$

Where E is energy (in joules), h is Planck's constant (6.62×10^{-34} Js), and is frequency (in seconds).

Electromagnetic radiation can be considered a combination of alternating electric and magnetic fields that travel through space with a wave motion. Because radiation acts as a wave, it can be classified in terms of either wavelength or frequency, which are related by the following equation:

$$v=c/\lambda$$

Where ν is frequency (in seconds), c is the speed of light (3×108 ms^{-1}), and λ is wavelength (in meters).

In UV-visible spectroscopy, wavelength usually is expressed in nanometers (1 nm = 10^{-9} m). It follows from the above equations that radiation with shorter wavelength has higher energy. In UV-visible spectroscopy, the low-wavelength UV light has the highest energy. In some cases, this energy is sufficient to cause unwanted photochemical reactions when measuring sample spectra (remember, it is the UV component of light that causes sunburn).

When radiation interacts with matter, a number of processes can occur, including reflection, scattering, absorbance, fluorescence/phosphorescence (absorption and reemission), and photochemical reaction (absorbance and bond breaking). In general, when measuring UV-visible spectra, we want only absorbance to occur. Because light is a form of energy, absorption of light by matter causes the energy content of the molecules (or atoms) to increase. The total potential energy of a molecule generally is represented as the sum of its electronic, vibrational, and rotational energies:

$$E_{total}=E_{electronic} + E_{vibrational} + E_{rotational}.$$

The amount of energy a molecule possesses in each form is not a continuum but a series of discrete levels or states. The differences in energy among the different states are in the order:

$$E_{electronic} > E_{vibrational} > E_{rotational}.$$

In some molecules and atoms, photons of UV and visible light have enough energy to cause transitions between the different electronic energy levels. The wavelength of light absorbed is that having the energy required to move an electron from a lower energy level to a higher energy level.

2-1-1 light interaction with matter:

When optical radiation interacts with matter, it may be reflected, absorbed, or transmitted.

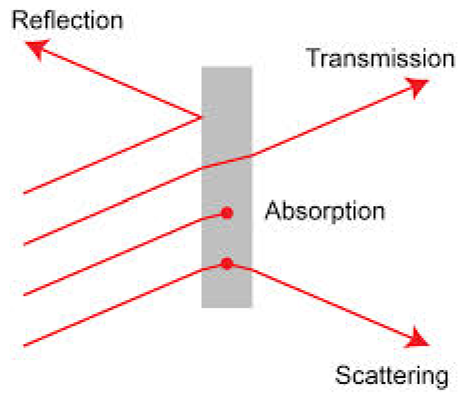

Figure 2.1 Describe how light interaction with matter:

2-1-2 Absorption:

If a light wave of a given frequency strikes a material with electrons having the same vibrational frequencies, then those electrons will absorb the energy of the light wave and transform it into vibrational motion. During its vibration, the electrons interact with neighboring atoms in such a manner as to convert its vibrational energy into thermal energy. Subsequently, the light wave with that given frequency is absorbed by the object .It is the transformation of radiant power to another type of energy, usually heat, by interaction with matter. In physics, absorption of electromagnetic radiation is the way in which the energy of a photon is taken up by matter, typically the electrons of an atom. Thus, the electromagnetic energy is transformed into internal energy of the absorber, for example thermal energy. The reduction in intensity of a light wave propagating through a medium by absorption of a part of its photons is often called attenuation. Usually, the absorption of waves does not depend on their intensity (linear absorption), although in certain conditions (usually, in optics), the medium changes its transparency dependently on the intensity of waves going through, and saturable absorption (or nonlinear absorption) occurs. The absorbance of an object quantifies how much of the incident light is absorbed by it. This may be related to other properties of the object through the Beer–Lambert law. The absorption coefficient determines how far into a material light of a particular wavelength can penetrate before it is absorbed. In a material with a low absorption coefficient, light is only poorly absorbed, and if the material is thin enough, it will appear transparent to that wavelength. The absorption coefficient depends on the material and also on the wavelength of light which is being absorbed. Semiconductor materials have a sharp edge in their absorption coefficient, since light which has energy below the band gap does not have sufficient energy to excite an electron into the conduction band from the valence band.

2-1-3 Reflection:

Reflection is the process by which electromagnetic radiation is returned either at the boundary between two media (surface reflection) or at the interior of a medium (volume reflection) .it is the change in direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated. Common examples include the reflection of light, sound and water waves. The law of reflection says that for specular reflection the angle at which the wave is incident on the surface equals the angle at which it is reflected. Mirrors exhibit specular reflection. Reflection of light is either specular (mirror-like) or diffuse depending on the nature of the interface. In specular reflection the phase of the reflected waves depends on the choice of the origin of coordinates. (Wikipedia, 2015). Diffuse reflection happen when light strikes the surface of a (non-metallic) material it bounces off in all directions due to multiple reflections by the microscopic irregularities inside the material and by its surface, if it is rough. Thus, an 'image' is not formed. This is called diffuse reflection. The exact form of the reflection depends on the structure of the material. Reflection and transmission of light waves occur because the frequencies of the light waves do not match the natural frequencies of vibration of the objects.

2-1-4 Transmission:

It is the passage of electromagnetic radiation through a medium .The transmittance of a material is the proportion of the incident (approaching) light that moves all the way through to the other side.

For example, let's say you're shining a flashlight on a semi-transparent glass block. You start off with 100% of your incident light. The first thing that happens is that 30% of that light is reflected off the outer surface of the glass. That leaves you with 70% to continue through the glass block. Another 50% of the light is absorbed by the molecules inside the glass block itself. That leaves you with 20% that immerges from the opposite side. So you could say that the glass block has a transmittance of 20%.

The transmittance of a material depends on its thickness, but it also depends on the type of 'light' (or electromagnetic waves) you are using. A material might have a different transmittance for visible light than it does for infrared, or x-rays. This is why hospital x-rays go through your skin until they reach the bones, even though visible light does not.

2-1-5 Light Scattering:

Light scattering can be thought of as the deflection of a ray from a straight path, for example by irregularities in the propagation medium, particles, or in the interface between two media. Deviations from the law of reflection due to irregularities on a surface are also usually considered to be a form of scattering. Most objects that one sees are visible due to light scattering from their surfaces (Kerker,M.1969) (Mandelstam ,L.I.1928). Indeed, Scattering of light depends on the wavelength or frequency of the light being scattered. Since visible light has wavelength on the order of a nanometer, objects much smaller than this cannot be seen, even with the aid of a microscope. (Vande Hulst .H.C 1981) (Bohren, C.F and Huffman, D.R 1983)

2-1-6 Relation between Reflectance, Transmission and Absorption:

In general, reflection, transmission and absorption depend on the wavelength of the affected radiation. Thus, these three processes can either be quantified for monochromatic radiation. In addition, reflectance, transmittance and absorbance might also depend on polarization and geometric distribution of the incident radiation, which therefore also has to be specified. The reflectance(r) is defined by the ratio of reflected radiant power to incident radiant power. The transmittance (t) of a medium is defined by the ratio of transmitted radiant power to incident radiant power. The absorbance (a) of a medium is defined by the ratio of absorbed radiant power to incident radiant power. Being defined as ratios of radiant power values

By Kirchhoff's radiation law, the flux emitted by a hot object must be equal to the amount absorbed by it; therefore, the emittance of an object must be equal to

$$a + r + t = 1$$

As all light that is neither reflected nor transmitted must be absorbed the difference (1-r-t) is equal to the absorption (a). In a rough approximation we could now calculate the absorption coefficient (α) according to the equation:

$$R + T = e^{-\alpha d}$$

Where d is the thickness of the sample. (Grolik Benno, Kopp Joachim 2003)

Reflectance, transmittance and absorptance are dimensionless.

The optical properties of materials are not a constant since they are dependent on many parameters such as:

- Thickness of the sample
- Surface conditions
- Angle of incidence
- Temperature (Gigahertz-opitks, 2015).

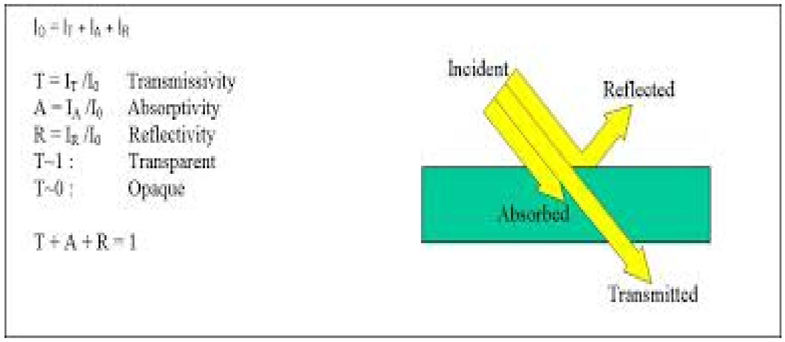

Figure (2-2) Describe the Relation between Reflectance, Transmission and Absorption:

2-2 Laser

Lasers are devices that produce intense beams of light which are monochromatic, coherent, and highly collimated. The wavelength (color) of laser light is extremely pure (monochromatic) when compared to other sources of light, and all of the photons (energy) that make up the laser beam have a fixed phase relationship (coherence) with respect to one another. Light from a laser typically has very low divergence. It can travel over great distances or can be focused to a very small spot with a brightness which exceeds that of the sun. Because of these properties, lasers are used in a wide variety of applications in all walks of life (Hitz, Ewing and Hecht).

2-2-1 laser classification:

Lasers can be classified according to various criteria, for examples wavelengths (regions of the spectrum at laser emits it is light), and the mode of operation (CW or Pulsed) sometimes used as a classification. Also according to the active medium laser are classified to:

Class I Lasers are safe under reasonably foreseeable conditions of operation, but may be hazardous if the user employs optics within the beam. lasers are low powered devices that are considered safe from all potential hazards. Some examples of Class I laser use is: laser printers, CD players, CD ROM devices. No individual, regardless of exposure conditions to the eyes or skin, is expected to be injured by a Class I laser. No safety requirements are needed to use Class I laser devices.

Class II lasers (Visible Lasers: 400 to 700 nm) are low power (< 1mW), visible light lasers that could possibly cause damage to a person's eyes. Some examples of Class II laser use are: laser pointers, aiming devices and range finding equipment. If class II laser beams are directly viewed for long periods of time (i.e. > 15 minutes) damage to the eyes could result. Avoid looking into a Class II laser beam or pointing a Class II laser beam into another person's eyes. Avoid viewing Class II laser beams with telescopic devices. Realize that the bright light of a Class II laser beam into your eyes will cause a normal reaction to look away or close your eyes. This response is expected to protect you from Class II laser damage to the eyes.

Class IIIa Lasers that emit in the wavelength range from 302,5 nm to 10^6 nm where direct intra beam viewing is potentially hazardous but the risk is lower than for Class IIIb lasers. Lasers are continuous wave, intermediate power (1-5 mW) devices.

Some examples of Class IIIa laser uses are the same as Class II lasers with The most popular uses being laser pointers and laser scanners. Direct viewing of the Class IIIa laser beam could be hazardous to the eyes. Do not view the Class IIIa laser beam directly. Do not point a Class IIIa laser beam into another person's eyes. Do not view a Class IIIa laser beam with telescopic devices; this amplifies the problem.

Class IIIb lasers are intermediate power (c.w. 5-500 mW or pulsed 10 J/cm^2) devices. Some examples of Class IIIb laser uses are CW and pulsed dye Lasers used in spectroscopy and entertainment light shows. Direct viewing of The Class IIIb laser beam is hazardous to the eye and diffuse reflections of the Beam can also be hazardous to the eye. Do not view the Class IIIb laser beam directly. Do not view a Class IIIb laser beam with telescopic devices; This amplifies the problem.

Class IV lasers are high power (c.w. >500mW or pulsed >10J/cm²) devices.

Examples of Class IV laser are: Argon ion and Nd: YAG lasers used to pump CW and pulsed dye lasers. The direct beam and diffuse reflections from Class IV lasers are hazardous to the eyes and skin. Class IV laser devices can also be a fire hazard depending on the reaction of the target when struck. Much Greater controls are required to ensure the safe operation of this class of laser Devices. Whenever occupying a laser controlled area, wear the proper eye Protection. Most laser eye injuries occur from reflected beams of class IV Laser light, so keep all reflective materials away from the beam. Do not place Your hand or any other body part into the class IV laser beam. The pain and Smell of burned flesh will let you know if this happens. Realize the dangers Involved in the use of Class IV lasers and please use common sense (Michael Drewsen, 2015).

2-2-2 Laser Hazards:

The laser produces an intense, highly directional beam of light. If directed, reflected, or focused upon an object, laser light will be partially absorbed, raising the temperature of the surface and/or the interior of the object, potentially causing an alteration or deformation of the material. These properties which have been applied to laser surgery and materials processing can also cause tissue damage there are two types of laser hazards laser beam hazard and the non beam hazard. Beam hazard Primary sites of damage in eye and skin.

2-2-2-1 Eye Hazards:

The major danger of laser light is hazards from beams entering the eye. The eye is the Organ most sensitive to light. Just as a magnifying glass can be used to focus the sun and burn wood, the lens in the human eye focuses the laser beam into a tiny spot than

can burn the retina. A laser beam with low divergence entering the eye can be focused down to an area 10 to 20 microns in diameter.
Normal focusing by the eye results in an irradiance amplification of roughly 100,000; therefore, a 1 mW/cm sq. beam entering the eye will result in a 100 W/cm sq. exposure at the retina. The most likely effect of intercepting a laser beam with the eye is a thermal burn which destroys the retinal tissue. Since retinal tissue does not regenerate, the damage is permanent. When IR laser light enters the eye, much of the light is absorbed in the lens. Depending on the level of exposure, this may cause immediate thermal burns. Light below 400 nm is not focused on the retina. The light can be ultraviolet (UV) from the pump light or blue light from a target interaction. The effect is cumulative over a period of days. If UV light from a pump light or blue light from a target interaction is emitted, additional precautions must be taken. When UV laser light enters the eye, much of the light is absorbed in the lens. Depending on the level of exposure, this may cause the development of cataracts over a period of years. Laser pulses of duration less than 10 microseconds induce a shock wave in the retinal tissue which causes a rupture of the tissue. This damage is permanent, as with a retinal burn. Acoustic damage is actually more destructive than a thermal burn. Acoustic damage usually affects a greater area of the retina, and the threshold energy for this effect is substantially lower. The cornea and the conjunctival tissue surrounding the eye can also be damaged by exposure to laser light. Damage to the cornea and conjunctival tissue usually occurs at greater power levels than damage to the retina; therefore, these issues only become a concern for those wavelengths that do not penetrate to the retina (i.e., UV and IR radiation). Since the amplification by the lens is not involved, the injuries can also be caused by diffuse and noncoherent light.

2-2-2-2 Laser Radiation Effects on Skin:

Lasers can harm the skin via photochemical or thermal burns. Depending on the

Wavelength, the beam may penetrate both the epidermis and the dermis. The epidermis is the outermost living layer of skin. Far and Mid-ultraviolet (the actinic UV) are absorbed by the epidermis. Sunburn (reddening and blistering) may result from short-term exposure to the beam. UV exposure is also associated with an increased risk of developing skin cancer and premature aging (wrinkles, etc) of the skin. Thermal burns to the skin are rare. They usually require exposure to high energy beams for an extended period of time. Carbon dioxide and other infrared lasers are most commonly associated with thermal burns, since this wavelength range may penetrate deeply into skin tissue. The resulting burn may be first degree (reddening), second degree (blistering) or third degree (charring).

2-2-3 Laser safety:

Laser safety is reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation and the individual to other hazards associated with laser devices during operation and maintenance.

2-2-3-1 Protection:

The types of personal protective equipment used include:

- Protective eyewear.
- Skin protection.

Although enclosure of the laser beam is the preferred method of protecting persons from exposure to laser radiation it is often necessary to perform work around open laser beams. In this case, eye and skin protection must be utilized to protect persons who might be exposed to stray beams of laser light (Prof. D Hahn,2015).

2-2-3-2 Protective eyewear:

Protective eyewear in the form of spectacles or goggles with appropriately filtering optics can protect the eyes from the reflected or scattered laser light with a hazardous beam power, as well as from direct exposure to a laser beam. Eyewear must be selected for the specific type of laser, to block or attenuate in the appropriate wavelength range. For example, eyewear absorbing 532 nm typically has an orange appearance, transmitting wavelengths larger than 550 nm. Such eyewear would be useless as protection against a laser emitting at 800 nm. Eyewear is rated for optical density (OD), which is the base-10 logarithm of the attenuation factor by which the optical filter reduces beam power. For example, eyewear with OD 3 will reduce the beam power in the specified wavelength range by a factor of 1,000. In addition to an optical density sufficient to reduce beam power to below the maximum permissible exposure, laser eyewear used where direct beam exposure is possible should be able to withstand a direct hit from the laser beam without breaking for at least 10 seconds. The protective specifications (wavelengths and optical densities) are usually printed on the goggles, generally near the top of the unit. Therefore, in selecting protective eyewear two characteristics must be considered:

- Optical density.
- Damage threshold.

The optical density of protective eyewear depends on the wavelength of the incident light. While most protective eyewear offers protection over a range of wavelengths, not all of the wavelengths will be attenuated to the same extent. Therefore, in selecting protective eyewear it is important to ensure that the optical density of the eyewear is adequate for the wavelength of interest.

The other factor that is important in selecting protective eyewear is the damage threshold specified by the manufacturer. The damage threshold is the level of irradiance above which damage to the filter will occur from thermal effects after a specified period of time - usually 10 seconds. Once the damage threshold is exceeded, the filter ceases to offer any protection from the laser radiation and serious injury can result. The damage threshold varies with the type of material used in the filter and some typical ranges are given below:

Table (2-1) type of material and its damage threshold:

Type of Material	**Damage Threshold (W/cm2)**
Plastic	1 – 100
Glass	100 – 500
Coated Glass	500 - 1,000

Protective eyewear must be clearly labeled with the optical density and wavelength for which protection is provided.

Protective eyewear must be regularly cleaned and inspected for pitting, crazing, cracking, discoloration, mechanical integrity, the presence of light leaks or coating damage. When damage is suspected the protective eyewear should be either retested for acceptability or discarded. When purchasing protective eyewear the wavelength, optical density, damage threshold, shelf life, storage conditions and limitations for use should be requested from the manufacturer before the purchase is made. This will ensure that the eyewear is adequate for the anticipated conditions of use (Prof. D Hahn,2015).

Additional factors Consider when selecting eyewear:

- Laser Power and/or pulse energy
- Mode of operation (continuous wave or pulsed)
- Maximum exposure duration.
- Maximum irradiance (W/cm^2) or radiant exposure (J/cm^2)
- Exposure time
- Maximum Permissible Exposure (MPE)

2-3 Laser Safety Filters:

2-3-1Basics of optical filters

Due to the unique characteristics of laser radiation (i.e. coherent, collimated and monochromatic) there is an increased danger to the eyes. Therefore special optical filters that transmit 'normal' light but block laser light must be used.

Since laser light has a specific wavelength which is dependent on the laser active medium that emits light, protective filters that match the wavelength and power of the specific source of laser radiation are needed.

Optical filters are devices that selectively transmit light of different wavelengths, usually implemented as plane glass or plastic devices in the optical path which are either dyed in the bulk or have interference coatings. Optical filters are completely described by their frequency response, which specifies how the magnitude and phase of each frequency component of an incoming signal is modified by the filter.

Filters mostly belong to one of two categories. The simplest, physically, is the absorptive filter; then there are interference or dichroic filters.

Optical filters selectively transmit light in a particular range of wavelengths, that is, colors, while blocking the remainder. They can usually pass long wavelengths only (long pass), short wavelengths only (short pass), or a band of wavelengths, blocking both longer and shorter wavelengths (band pass). The pass band may be narrower or wider; the transition or cutoff between maximal and minimal transmission can be sharp or gradual. There are filters with more complex transmission characteristic, for example with two peaks rather than a single band; these are more usually older designs traditionally used for photography; filters with more regular characteristics are used for scientific and technical work.

Optical filters are commonly used in photography (where some special effect filters are occasionally used as well as absorptive filters), in many optical instruments, and to color stage lighting. In astronomy optical filters are used to restrict light passed to the spectral band of interest, e.g., to study infrared radiation without visible light which would affect film or sensors and overwhelm the desired infrared. Optical filters are also essential in fluorescence applications such as fluorescence microscopy and fluorescence spectroscopy.

Photographic filters are a particular case of optical filters, and much of the material here applies. Photographic filters do not need the accurately controlled optical properties and precisely defined transmission curves of filters designed for scientific work, and sell in larger quantities at correspondingly lower prices than many laboratory filters. Some photographic effect filters, such as star effect filters, are not relevant to scientific work.

2-3-2Type of optical filters

Absorptive filters:

Absorptive filters are usually made from glass to which various inorganic or organic compounds have been added. These compounds absorb some wavelengths of light while transmitting others. The compounds can also be added to plastic (often polycarbonate or acrylic) to produce gel filters, which are lighter and cheaper than glass-based filters.

Dichotic filters:

Alternately, dichotic filters (also called "reflective" or "thin film" or "interference" filters) can be made by coating a glass substrate with a series of optical coatings. Dichotic filters usually reflect the unwanted portion of the light and transmit the remainder.

Dichroic filters use the principle of interference. Their layers form a sequential series of reflective cavities that resonate with the desired wavelengths. Other wavelengths destructively cancel or reflect as the peaks and troughs of the waves overlap.

Dichroic filters are particularly suited for precise scientific work, since their exact color range can be controlled by the thickness and sequence of the coatings. They are usually much more expensive and delicate than absorption filters.

They can be used in devices such as the dichotic prism of a camera to separate a beam of light into different colored components.

The basic scientific instrument of this type is a Fabry–Pérot interferometer. It uses two mirrors to establish a resonating cavity. It passes wavelengths that are a multiple of the cavity's resonance frequency.

Etalons are another variation: transparent cubes or fibers whose polished ends form mirrors tuned to resonate with specific wavelengths. These are often used to separate channels in telecommunications networks that use wavelength division multiplexing on long-haul optic fibers.

Monochromatic filters:

Monochromatic filters only allow a narrow range of wavelengths (essentially a single color) to pass.

Infrared filters:

The term "infrared filter" can be ambiguous, as it may be applied to filters to pass infrared (blocking other wavelengths) or to block infrared (only).

Infrared-passing filters are used to block visible light but pass infrared; they are used, for example, in infrared photography.

Infrared cut-off filters are designed to block or reflect infrared wavelengths but pass visible light. Mid-infrared filters are often used as heat-absorbing filters in devices with bright incandescent light bulbs (such as slide and overhead projectors) to prevent unwanted heating due to infrared radiation. There are also filters which are used in solid state video cameras to block IR due to the high sensitivity of many camera sensors to unwanted near-infrared light.

Ultraviolet filters:

Ultraviolet (UV) filters block ultraviolet radiation, but let visible light through. Because photographic film and digital sensors are sensitive to ultraviolet (which is abundant in skylight) but the human eye is not, such light would, if not filtered out, make photographs look different from the scene visible to people, for example making images of distant mountains appear unnaturally hazy. An ultraviolet-blocking filter renders images closer to the visual appearance of the scene.

As with infrared filters there is a potential ambiguity between UV-blocking and UV-passing filters; the latter are much less common and more usually known explicitly as UV pass filters and UV band pass filters.

Neutral density filters:

Neutral density (ND) filters have a constant attenuation across the range of visible wavelengths, and are used to reduce the intensity of light by reflecting or absorbing a portion of it. They are specified by the optical density (OD) of the filter, which is the negative of the common logarithm of the transmission coefficient. They are useful for making photographic exposures longer. A practical example is making a waterfall look blurry when it is photographed in bright light. Alternatively, the photographer might want to use a larger aperture (so as to limit the depth of field); adding an ND filter permits this. ND filters can be reflective (in which case they look like partially reflective mirrors) or absorptive (appearing grey or black).

Long pass filters:

A long pass (LP) Filter is an optical interference or colored glass filter that attenuates shorter wavelengths and transmits (passes) longer wavelengths over the active range of the target spectrum (ultraviolet, visible, or infrared). Long pass filters, which can have a very sharp slope (referred to as edge filters), are described by the cut-on wavelength at 50 percent of peak transmission. In fluorescence microscopy, long pass filters are frequently utilized in dichroic mirrors and barrier (emission) filters. Use of the older term 'low pass' to describe long pass filters has become uncommon; filters are usually described in terms of wavelength rather than frequency, and a "low pass filter", without qualification, would be understood to be an electronic filter.

Band passes filters:

Band pass filters only transmit a certain wavelength band, and block others. The width of such a filter is expressed in the wavelength range it lets through and can be anything from much less than an Angstrom to a few hundred nanometers. Such a filter can be made by combining an LP- and an SP filter.

Examples of band pass filters are the Lyot filter and the Fabry-Pérot interferometer. Both of these filters can also be made tunable, such that the central wavelength can be chosen by the user. Bandpass filters are often used in astronomy when one wants to observe a certain process with specific associated spectral lines. The Dutch Open Telescope and Swedish Solar Telescope are examples where Lyot and Fabry-Pérot filters are being used.

Shortpass filters:

A short pass (SP) Filter is an optical interference or coloured glass filter that attenuates longer wavelengths and transmits (passes) shorter wavelengths over the active range of the target spectrum (usually the ultraviolet and visible region). In fluorescence microscopy, short pass filters are frequently employed in dichromatic mirrors and excitation filters.

Guided-mode resonance filters:

A relatively new class of filters introduced around 1990. These filters are normally filters in reflection, that is they are notch filters in transmission. They consist in their most basic form of a substrate waveguide and a sub wavelength grating or 2D hole array. Such filters are normally transparent, but when a leaky guided mode of the waveguide is excited they become highly reflective (a record of over 99% experimentally) for a particular polarization, angular orientations, and wavelength range. The parameters of the filters are designed by proper choice of the grating parameters. The advantage of such filters are the few layers needed for ultra-narrow bandwidth filters (in contrast to dichroic filters), and the potential decoupling between spectral bandwidth and angular tolerance when more than 1 mode is excited.

Metal mesh filters:

Filters for sub-millimeter and near infrared wavelengths in astronomy are metal mesh grids that are stacked together to form LP, BP, and SP filters for these wavelengths.

Polarizer filters:

Another kind of optical filter is a polarizer or polarization filter, which blocks or transmits light according to its polarization. They are often made of materials such as Polaroid and are used for sunglasses and photography. Reflections, especially from water and wet road surfaces, are partially polarized, and polarized sunglasses will block some of this reflected light, allowing an angler to better view below the surface of the water and better vision for a driver. Light from a clear blue sky is also polarized, and adjustable filters are used in color photography to darken the appearance of the sky without introducing colors to other objects, and in both color and black-and-white photography to control specular reflections from objects and water. Much older than g.m.r.f (just above) these first (and some still) use fine mesh integrated in the lens.

Polarized filters are also used to view certain types of stereogram, so that each eye will see a distinct image from a single source.

Arc welding filters:

An arc source puts out visible light that may be harmful to human eyes. Therefore, optical filters on welding helmets must meet ANSI Z87:1 (safety glasses specification) in order to protect human vision.

Some examples of filters that would provide this kind of filtering would be earth elements embedded or coated on glass, but practically speaking it is not possible to do perfect filtering. A perfect filter would remove particular waves and leave plenty of light so a worker can see what he/she is working on.

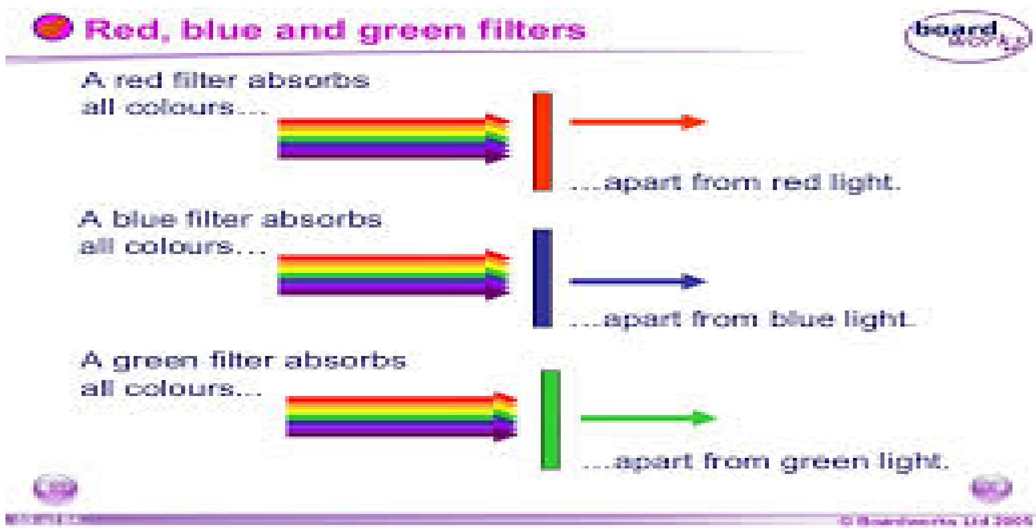

Figure (2-3) Diagram of optical filters.

2-3-2-1 Filters Transmission changes caused by intense ultraviolet radiation:

Prolonged exposure to intense light sources with high ultraviolet radiation can Cause permanent changes (reductions) in the transmissions of filter glasses. In glass technology this effect is called "solarization". It is mainly a function of the intensity and spectral distribution of the radiation. The more shortwave the radiation is, the higher is the solarization effect.

The solarization effect itself manifests mainly by a shift of the short wave located edge to longer wavelengths and a reduction of the transmission in the pass range. Depending on the spectral distribution, intensity and duration of the irradiation, a saturation effect will set in. If the transmittance curve, resulting from such an effect, is acceptable for the application, such a glass can be "aged" prior to use by exposing it to an appropriate pre-irradiation.

KG heat protection filters for xenon lamps are an important example for such an application.

Since the solarization of a filter glass is strongly dependent upon the spectral Distribution and intensity of the light source, the duration and the geometrical Arrangement of the irradiation, no detailed information is given regarding Solarization. Filter glasses that are prone to higher solarization are identified

With the letter V in the data section

2-3-2-2 Optical Density (OD):

The Optical Density (OD) is the attenuation of light that passes through an optical filter. The higher the OD value, the higher the attenuation. The mathematic expression of Optical Density is the logarithm to the base ten of the reciprocal of the transmittance and is given by the listed equation (where T is the transmittance).

$$OD = -\log_{10} T \quad \textbf{so} \quad T = 10^{-OD}$$

In other words, the Optical Density is a measure that indicates how many decimal places the transmission shifts at the required wavelength. But according to the above described standards the Optical Density alone is not sufficient enough to guarantee protection against laser radiation. It is important that the Optical Density will also remain high enough in case of a direct laser hit on the filter. This requirement seems to be trivial, but there are indeed some interaction effects of filter and laser radiation, which can cause some reduction of the Optical Density.

In order to make sure that the protection remains stable even under direct laser illumination, laser safety goggles (filter and frame) are subject to standardised laser safety tests performed by independent and accredited laboratories.

In principle there are two different strategies for selective filtering of light – absorption and reflection (GmbH & Co. KG 2015).

2-3-2-3 Daylight Transmission (VLT) and Color Vision:

When wearing laser safety glasses some wavelengths of the spectrum that would normally reach our eyes are filtered out. This means, if light from the visible region is blocked, this will inevitably change the perception of the environment as well. First, by attenuation of the transmission the environment gets darker (similar to the effect of sun glasses). Second, blocking some wavelengths changes our perception of color.

The attenuation of light by a filter with the transmission τF (λ) in the visible spectrum is defined by the so-called VLT (visible light transmission) the daylight transmission or the luminous transmittance. The VLT is determined in relation to the standard illuminant and evaluated according to the spectral sensitivity of the eye to daylight.

Should the measured VLT-value be less than 20 %, the user should ensure that their working environment receives additional illumination. With a low VLT and bad illumination one can expect our eyes to adapt to so-called night vision. In doing so, the color vision is restricted and the spectral sensitivity of the eyes moves towards the shorter wavelengths. For these kinds of filters it is also useful to provide the VLT-value for night vision (GmbH & Co. KG).

2-3-2-4 Color Vision:

The eyes can adapt to different light situations and the total amount of light can be balanced by additional illumination. Therefore another important aspect for the selection of a laser safety filter is color vision. If color vision is impaired or restricted, some colors may not be recognized. This effect may also apply to warning lights or displays, or the ability to distinguish between instruments or vessels marked by color such as those found in medical surroundings (GmbH & Co. KG,2015).

There are different approaches to describe the color vision of a filter. The color of laser safety filters should also be carefully considered. The example given earlier of a filter designed to protect against a red or near infrared laser will mean that red colors are simply not visible. This can be a severe problem in certain applications, particularly in medicine. The same filter will also not allow the wearer to see red warning signs.

Table (2-2) Gives pairs of complementary colors absorbed and the wavelengths:

Wavelength (nm)	Color Absorbed
400	Violet
435	Blue
495	Green
560	Yellow
650	Orange
800	Red

2-3-3 Types of Laser Safety Eyewear:

Glass:

Glass laser eyewear is heavier and more costly than plastic, but it provides better visible light transmittance. There are two types of glass lenses, those with absorptive glass filters and those with reflective coatings. Reflective coatings can create specular reflections and the coating can scratch, minimizing the protection level of the eyewear.

Polycarbonate:

Polycarbonate laser eyewear is lighter, less expensive and offers higher impact resistance than glass, but allows less visible light transmittance.

Diffuse Viewing Only (DVO):

As the name implies, DVO eyewear is to be used when there is a potential for exposure to diffuse reflections only. DVO eyewear may not provide protection from the direct beam or specular reflections.

Alignment Eyewear:

Alignment eyewear may be used when aligning low power visible laser beams. Alignment eyewear transmits enough of the specified wavelength to be seen for alignment purposes, but not enough to cause damage to the eyes. Alignment eyewear cannot be used during operation of high power or invisible beams and cannot be used with pulsed lasers.

2-3-3-1 Filters with Reflective Coatings:

LASERVISION Company offers technically advanced laser safety eyewear with high optical density filters constructed by the vacuum vapour deposition of dielectric interference layers onto a clear glass or plastic substrate. The design of the interference layers of the coating materials determines which wavelengths are reflected and which are transmitted. The individual coating layers have to be applied to an accuracy of a few nanometers. For the so-called blocked laser wavelength, a constructive multiple reflection is achieved and the filter reflects nearly all of the laser light. , the interference layers completely block all wavelengths for which the filter is designed over a range of incident angles of 30 degrees.

With the exception of the blocked wavelengths, nearly all light passes through the filter without attenuation. As a result, coated filters have a much better color vision and higher visible light transmission compared with absorbing glass and plastic filters. This can be especially important in medical applications.

Dielectric coated filters protect by reflecting the incident laser energy. As a result, the protection of such filters is highly independent of the substrate material. Therefore, it is possible to achieve high protection levels using coated plastic filters which avoid the penalty of heavy or thick absorbing glass filters.

2-3-3-2 Glass and Plastic Absorption Filters:

Absorbing materials are the common standard in order to block light of a defined wavelength area from the spectrum. For the basic material special optic filter glass or amorphous polymers with special absorber dyes are mostly used. Absorption means that the light energy of the specified wavelength for which the filter is designed for is transformed to heat, when the beam hits the filter. Therefore it is necessary to select the filter material carefully for thermal stability in order to protect against a direct hit.

Each of the different materials used for absorption filters, plastics and glass, does have advantages and disadvantages with respect to protection and comfort and also possible damage symptoms are quite different when hit by a laser. Plastic filters will carbonize at high power densities and can be quickly penetrated.

Glass filters will break due to the thermal distortion in cases where the damage threshold is exceeded. That's why laser vision glass filters are enhanced by splinter protection (lamination with neutral glass) as standard to avoid injuries in case of a hazardous situation. In addition, the splinter protection will also keep the protection effective. Even a cracked filter will keep the required Optical Density as long as the pieces remain together. Glass filters are not only of higher value but are clearly superior to plastic filters in terms of the thermal stability of the filter material. Therefore they are especially suitable for continuous lasers (cw operation) of medium to high power.

Laser safety eyewear made from plastics is especially characterized by low weight and therefore features a high wearing comfort. In most cases it consists of a single shield with temples which can be used in dependence of the design also over prescription glasses. Some manufacturers (for example LASERVISION) offer also very sportive single shield designs with a very good field of view. But there are of course also spectacles available with two curved filters and good fit.

In contrast to this, glass filters are, especially for high power industrial cw lasers, the only possible way to achieve the high protection levels required by the norms. Additionally the combination of different absorbing glass filters offers the possibility to customize laser safety eyewear specific to an application. Usually the eyewear comes as a goggle or spectacle with two ground filters glasses. The thickness and therefore the weight of the filter do have significant influence on the wearing comfort. Therefore it is important to choose a manufacturer or model which offers options to allow an individual fit of the eyewear to the user. Suitable options can be different sets of temples, flexible head bands or support systems. For users who need to wear corrective glasses it must be possible get a model which can be worn over the glasses (GmbH & Co. KG,2015).

2-3-3-3 Identification of Eyewear:

To be considered legally certified laser protective eyewear, the eyewear must be labeled with its optical density and wavelength or wavelength range the eyewear is designed for. The laser manufacturer is only responsible for the wavelength marked on the eyewear (Ken Barat).

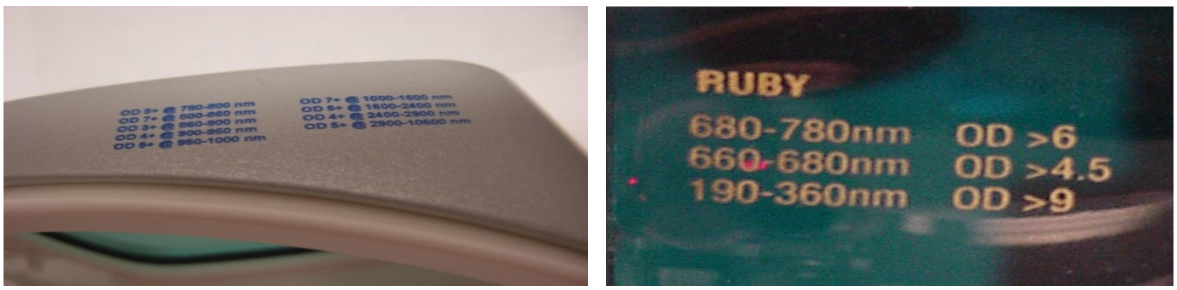

Figure (2.4) Description the Identification of Eyewear.

NOTE:
Commercial laser protective eyewear may have a duplicate labeling compliant with European Norm 207 as:

• D stands for continuous wave laser

• I stand for pulse laser

• R stands for Q Switched pulsed (pulse length 10^{-4} to 10^{-1} s)

• M stands for mode-coupled pulse laser (pulse length $<10^{-9}$ s)

• L stands for Scale number equivalent to OD, L1 = OD 1, L2 = OD 2 (Ken Barat,2011).

2-3-4 Instructions for care and cleaning:

Laser safety glasses are high value optical products. They need cleaning and care. Please follow these directions carefully to enable your glasses to protect you as long as possible.

Goggles, windows, filters and glasses with a damaged or scratched ocular or with filters that have undergone a color change should not be used anymore. Please return in the damaged product to the company you bought them from (or to the manufacturer) for checking or replace them with a new pair. When frames are equipped with a metal reinforcement on the inside, the reinforcement is a relevant part of the protection. When the reinforcement is damaged the protection may be impaired. Additional directives for used laser eye wear:

Do not expose the eyewear permanently to daylight or UV-lamps.

Protect the glasses from scratches and mechanical stress.

Avoid contact with chemicals, acids, and alkali and toxic (i.e. reactive) fumes.

Never put down the glasses with filters facing down.

Do not put the glasses on heaters or equipment that may heat up.

Store the glasses in dry and robust boxes; the original storage box is ideal

Avoid storage in high humidity; if that is not possible ensure good ventilation.

Glasses can clean with clear water and neutral cleaning agents (e.g. a mild, household glass cleaner) and dry them gently with a soft cloth.

Do not clean them dry – could grind them with small particles.

Never immerse them in water.

Do not use chemicals or acidic cleaning fluids for cleaning.

Do not immerse them in sterilization or disinfectant fluids!

Never clean them with ultrasonic waves (Ken Barat,2011).

Chapter Three
The Experimental Part

This chapter is presents all the systems and optical set used in the experimental part.

3.1Materials (Laser goggles):

In the first presents the items of the Laser goggle which specify by wavelength rang (1064-1048) nm is founded in laser clinic Sudan University referred it by S_1.

Figure 3.1. Goggle with wavelength (1064-1048) nm

In the second presents the items of the Laser goggle which specify by wavelength rang (532) nm is founded in laser clinic Sudan university referred it by S_2.

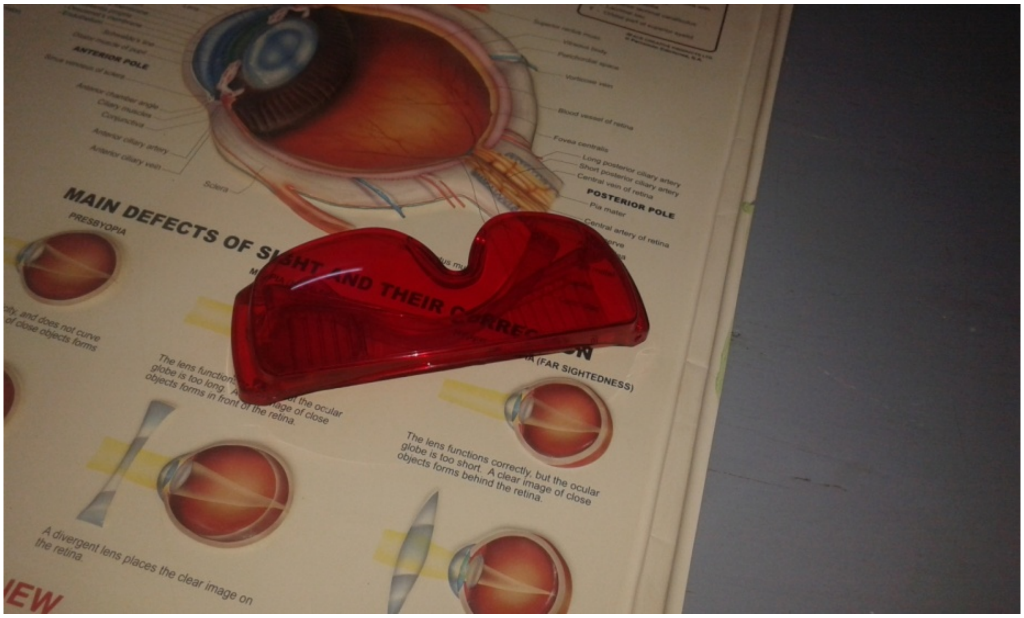

Figure 3.2. Goggle with wavelength 532 nm

In the third presents the items of the Laser goggle which specify by wavelength s rang (870-694and 830-904) nm is founded in laser clinic Sudan University referred it by $S_{3.}$

Figure 3.3. Goggle with wavelength (870-694and 830-904) nm

In the fourth presents the items of the Laser goggle which specify by wavelength s rang (190-380and 5000-11000) nm is founded in laser clinic Sudan University referred it by $S_{4.}$

Figure 3.4. Goggle with wavelength (190-380and 5000-11000) nm

In the fifth presents the items of the Laser goggle which specify by wavelength rang (800-920) nm and optical density 6(w/cm^2) is founded in laser clinic Sudan university of Science and Technology and referred it by S_5.

Figure 3.5. Goggle with wavelength 800-920 nm

The last from laser laboratory of al Neelain University referred it by S_6.

Figure 3.6. Goggle unsigned from al Neelain University

In the seventh presents the items of the Laser goggle which specification by multi wavelengths rang (190-380,755-855 and 760-840) nm and 0ptical density (7, 4 and 7) (w/cm^2) is founded in laser clinic Sudan University referred it by S_7.

Figure 3.7 Goggle with multi wavelengths (190-380,755-855 and 760-840) nm

In the last presents the items of the Laser goggle which specification by wavelength s rang (800-920) nm is founded in laser clinic Sudan university referred it by S_8.

Figure 3.8 Goggle with wavelength (800-920) nm

3.2 Instruments and Apparatus (UV-Vis Spectrophotometer):

The transmittance spectra of laser goggles were obtained by using the UV-Vis mini1240 Shimadzu spectrophotometer. Ultraviolet-visible spectrometry is absorption spectrometry in the UV-visible region that quantitatively determines solutions of transition metal ions and organic compounds. UV-Vis spectrophotometers compare the intensity of light before and when it passes through a sample. The Beer-Lambert law is applied to analyze concentrations of an absorbing species in solution.

While UV-Vis spectrometry is of limited use for sample identification, it is an effective tool for quantitative measurements. Applications include analysis of biochemical, chemicals, colors and dyes, proteins, and multicomponent formulations. These instruments can be found in pharmaceutical, biotech, polymer science, chemicals, forensics, and environmental analysis, food/beverage, and genomics laboratories.

There are three main components of a typical UV-Vis spectrometer, Plus a mechanism for holding the sample in place. The light source is either a diffraction grating or monochromatic. The detector can either be a photodiode (used with a monochromatic) or a CCD (used with diffraction gratings). The third component, the radiation source, was traditionally a tungsten filament; this has evolved into more advanced forms such as deuterium arc lamps, LED arc lamps, and xenon arc lamps.

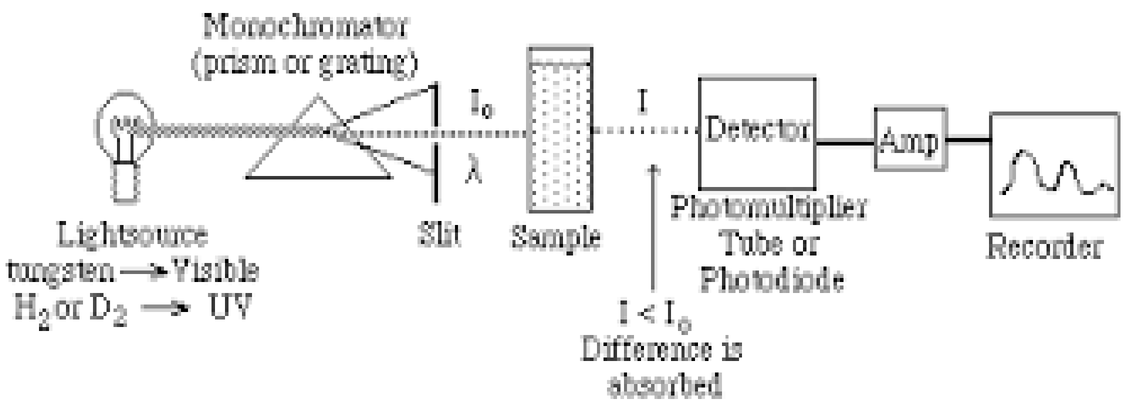

Figure 3.7. Schematic diagram of UV-Vis spectrometer

Figure 3.8. UV-Vis 1240 spectrometer

3.3 Method:

In this study we used direct measurement by used UV-Vis spectrometer to Obtain transmission spectra of laser goggles to determined block wavelengths rang of laser goggles. All laser goggles were cleaned, In the spectrophotometer the first laser Goggles was put in the sample position and the transmittance spectra was selected against the wavelength and spectrum was plotted then the experiment was repeated for all the laser goggles, all spectra were recorded and shown in the next chapter.

CHAPTER FOUR

RESULLTS AND DISCUSSION

In this chapter it presented and discuses the result of transmission measurement of laser goggles .First we present the result and discussion. Flowed by conclusion of this work and then finish by references.

4.1 The results and Discussion:

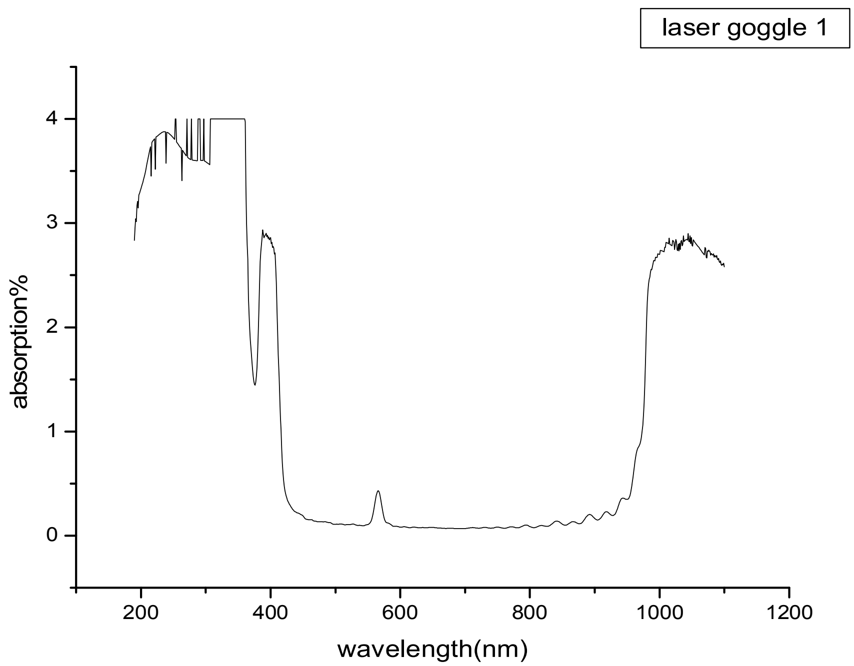

Figure 4.1. The spectrum of the S_1.

This spectrum for the sample S1 which specification by wavelength rang (1064-1048) nm, the maximum absorption in ultraviolet wavelengths rang, the minimum absorption value in visible light wavelengths range and the amount of absorption rang increase again in near infrared wavelengths range.

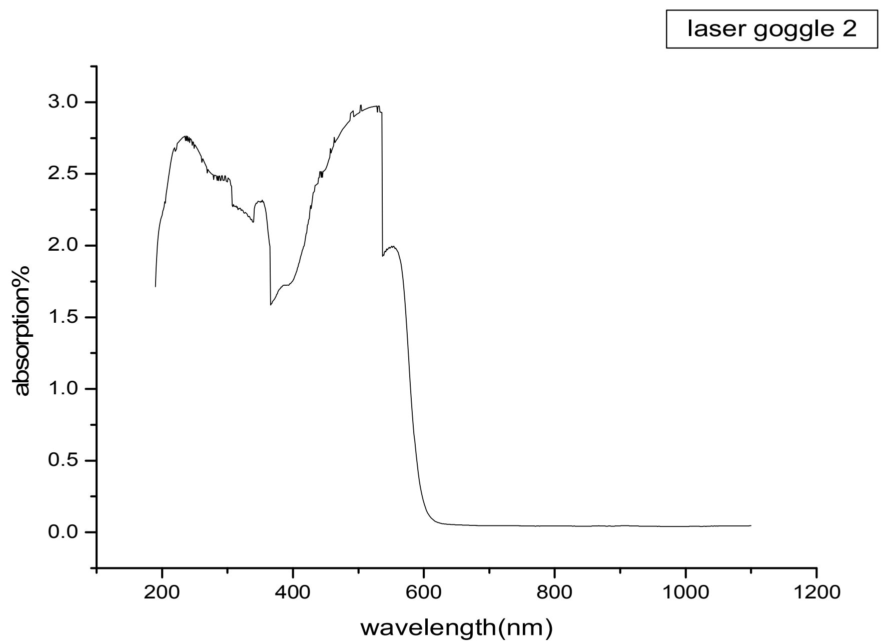

Figure 4.2. The spectrum of the S_2.

This spectrum referred to S_2 which specification by wavelength rang (532),their amount of absorption in ultraviolet wavelengths rang part of visible light(400-600) rang, and the amount of absorption decrease from 600 nm and next than1100 nm the part of near infrared wavelength range.

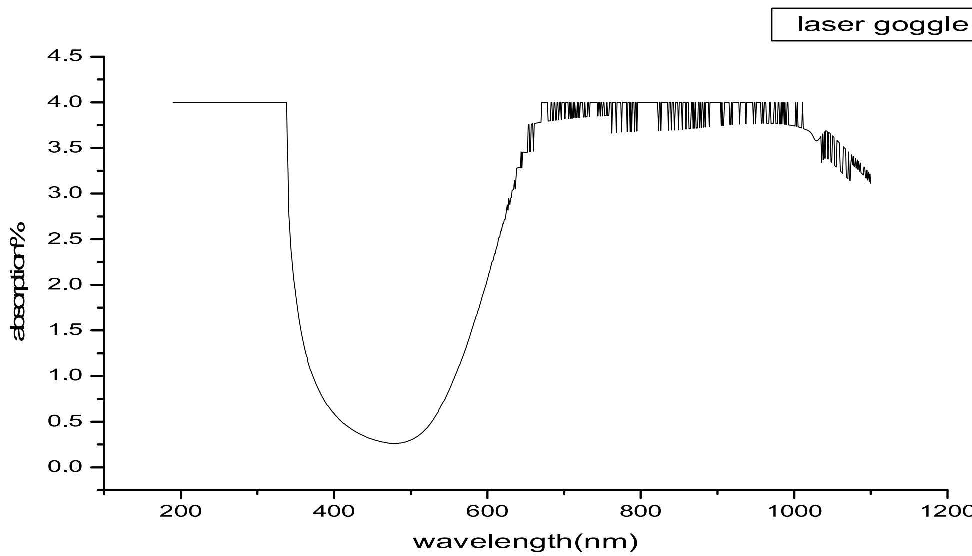

Figure 4.3. The spectrum of the S_3.

This spectrum referred to S_3 which specification by wavelength (694-870 and 830-904) ,their absorption in ultraviolet range .From (200-570) nm absorption reach the minimum volume, from (570-1100)nm the absorption again increase.

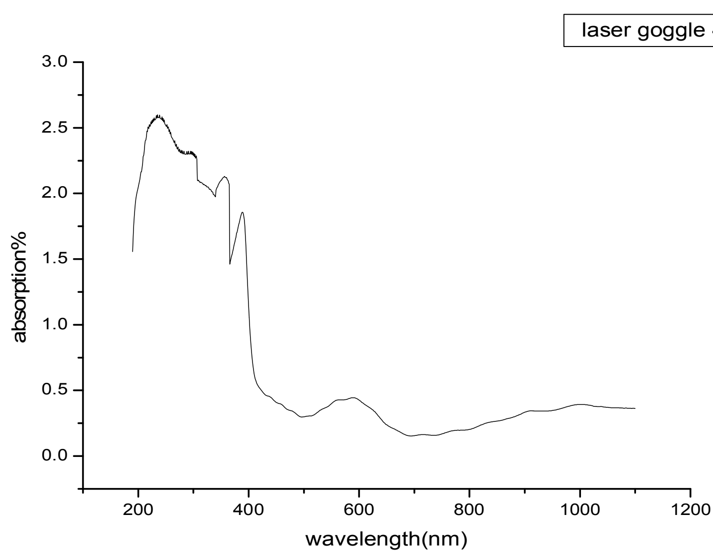

Figure 4.4. The spectrum of the S_4.

This spectrum referred to S_4 which specification by wavelength (800-920) nm, ultraviolet wavelengths rang the absorption had variant percent and the percent decrease from (400-1100) nm .

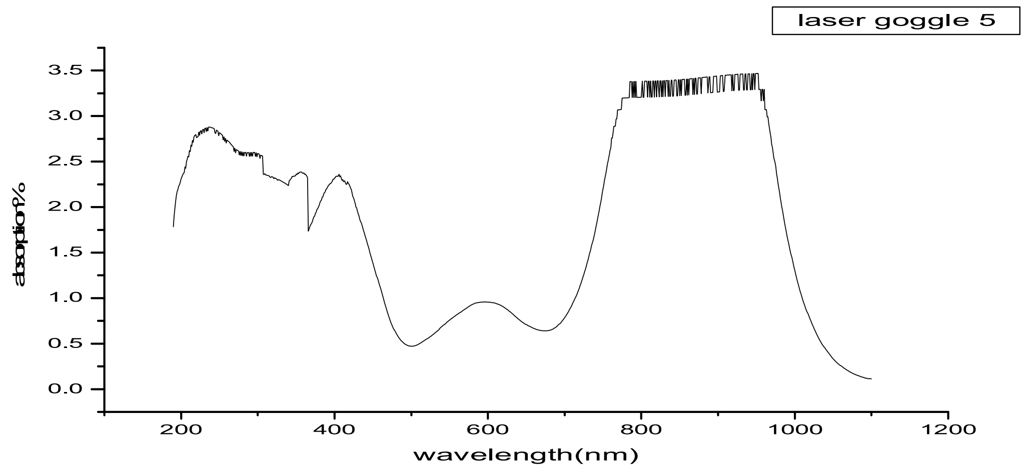

Figure 4.5. **The spectrum of the S_5.**

This spectrum referred to S_5 which specification by wavelength (800-920) , from (200-440)nm the absorption had variant percent, it decrease in visible light range and in near infrared it increase again.

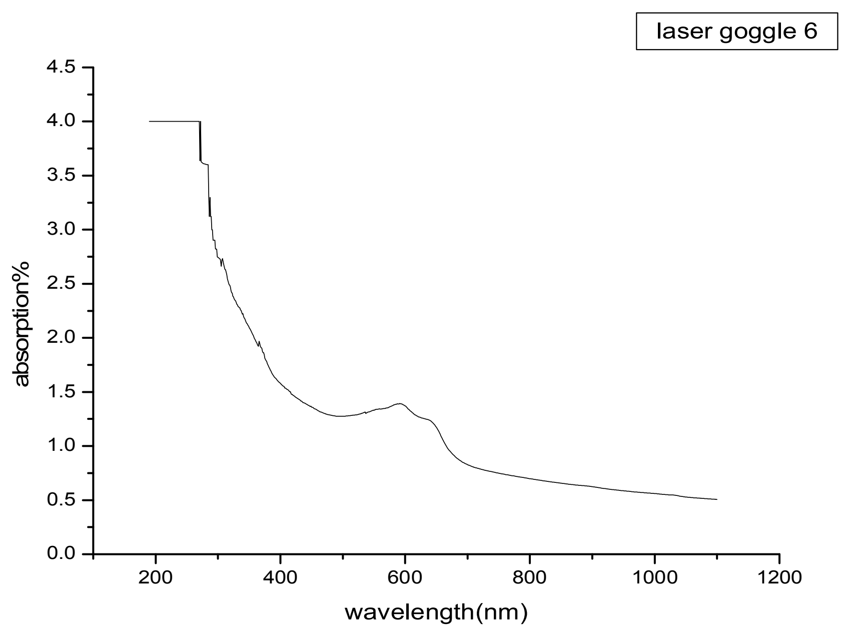

Figure 4.6. **The spectrum of the S_6.**

This spectrum referred to S_6 which is not specified by any wavelength it appears absorption band from (before 200 nm to 440 nm) the absorption decrease in visible light range and near infrared.

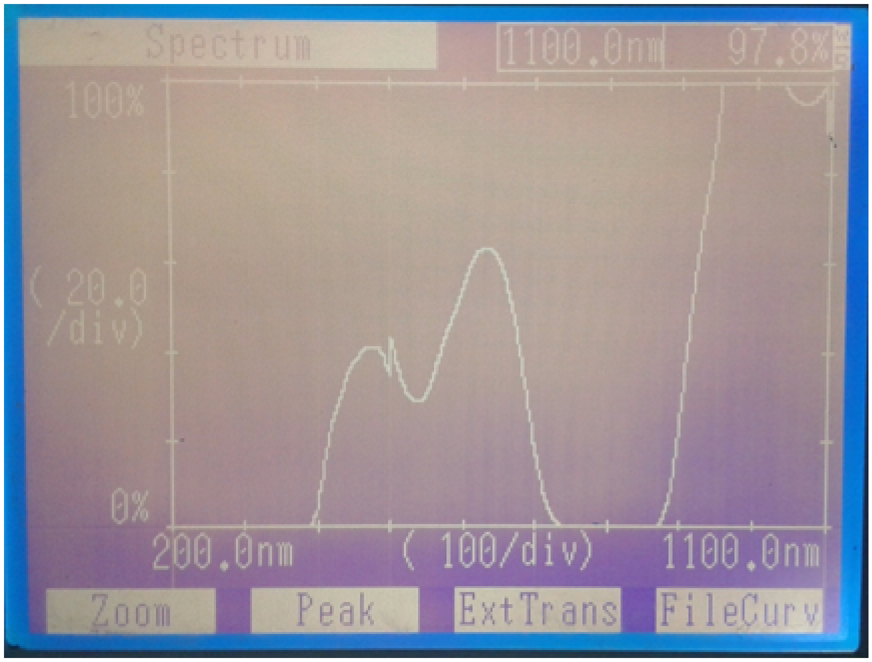

Figure 4.7. **The spectrum of the S_7**

This spectrum referred to S_2 which specification by wavelength rang (190-380,755-855) and the measured transmission wavelength rang is (200-390,730-880) nm

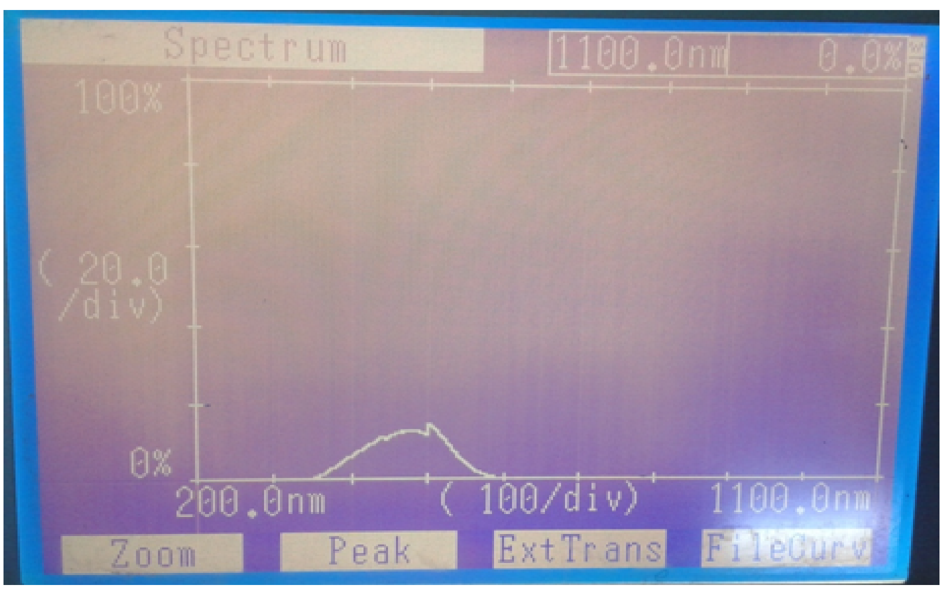

Figure 4.8. **The spectrum of the S_8**

This spectrum referred to S_8 which specification by wavelength (800-920) nm and the transmission measurement wavelength rang is (200-360,690-1100) nm.

Table (4-1) Represent consequence of transmission measurement of laser goggles:

Number of Google	Measurement absorbed wavelengths (nm)	Labeled absorbed wavelength (nm)	Suitable laser
S1	200-380,910-1100	1068-1064	Nitrogen, krypton, Excimer and diode lasers
S2	200-390,730-880	190-380,755-855 and 760-840	Excimer,diode lasers
S3	200-400	830-904	Excimer lasers
S4	200-400,920-1100	190-380,1046	Nitrogen, krypton, Excimer and diode lasers
S5	200-420,740-990	1800-930	Nitrogen, krypton, Excimer and diode lasers
S6	200-350,600-1100	Not sign	Excimer laser
S7	200-570	532	Ruby,Nd Q switch lasers
S8	200-360,690-1100	800-920	He-Ne, diode lasers

Discussion:

From the above results we can classification this eye wear filter into the following categories:

1. UV absorption filters include all samples.
2. Visible light absorption filter include zero samples.
3. Near IR absorption filter include samples (1 & 2&4&5&6 and 8).

The visible light transmission (VLT) its important factor when selecting laser safety glasses and must be not less than 20% because if light from the visible region is blocked by attenuation of the transmission the environment gets darker which it can make it difficult to see in laboratory, from above result most of laser goggles have VLT less than 20% except in s_1 and user should ensure that their working environment receives additional illumination

4-3 Conclusions:

All lasers goggles absorption measurements have same accuracy and its proper to use with type of Laser-In-Use, there is small shift in two absorption spectra refer to many factor as scratch, pitted, life shield and dust, cracking, discoloration. The shift in wavelength measurement according to affected temperature and storage condition. It shows from results that all goggles are proper to used with their lasers, and the two laser goggle which is referred it by S_1 and S_4 are used to protect from CO_2 laser with 10600 nm our uv-vis spectrometer it's not suitable to measure its wavelength rang.

Recommendations:

- For more precision when calibrated laser safety glasses the two lenses must be measured and cleaned carefully from dust and other foul.
- Required spectrometer have large rang to measure all wavelengths rang.
- wavelengths and optical densities must be printed on the goggles, generally near the top of the unit
- Store the glasses in dry and robust boxes; the original storage box is ideal.

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