Natural Phenomenon

Objectives

After going through the module, the learners will be able to,

Appreciate and understand natural optical phenomenon like-

- Scattering of light
- Blue color of sky
- Reddish appearance of the sun at sunrise and sunset
- Dust haze
- Colour of clouds
- Rainbow

Content Outline

- Unit syllabus
- Module-wise distribution of unit syllabus
- Words you must know
- Introduction
- Refraction through atmosphere
- Some natural phenomenon due to sunlight
- Passage of sunlight through atmosphere
- Summary

Unit Syllabus

UNIT 6: Optics

Chapter–9: Ray Optics and Optical Instruments

Ray optics: Reflection of light; spherical mirrors; mirror formula; refraction of light; total internal reflection and its applications; optical; fibres; refraction at spherical surfaces; lenses; thin lens formula; lens maker’s formula; magnification, power of a lens; combination of thin lenses in contact; refraction and dispersion of light through a prism.

Scattering of light – blue color of sky and reddish appearance of the sun at sunrise and sunset

Optical instruments – microscopes and astronomical telescopes (refracting and reflecting) and their magnifying powers

Chapter 10 Wave Optics

Wave optics: Wavefront and Huygens principle, reflection and refraction of plane wave at a plane surface using wave fronts, proof of laws of reflection and refraction using Huygens's principle. Interference, Young's double slit experiment and expression for fringe width, coherent sources and sustained interference of light; diffraction due to a single slit width of central maximum; resolving power of microscope and astronomical telescope. Polarisation, plane polarised light, Malus's law, Brewster's law, uses of plane polarised light and polaroid.

Module Wise Distribution Of Unit Syllabus-15 Modules

Module 1	• Introduction • How we will study optics-plan • Light facts • Ray optics, beams • Light falling on surfaces of any shape texture • Peculiar observations
Module 2	• Reflection of light • Laws of reflection • Reflection of light by plane and spherical surfaces • Spherical Mirrors aperture, radius of curvature, pole principal axis • Focus, Focal length, focal plane • Image – real and virtual • Sign convention • The mirror equation, magnification • To find the value of image distance v for different values of object distance u and find the focal length of a concave mirror • Application of mirror formula
Module 3	• Refraction of light • Optical density and mass density • Incident ray, refracted ray emergent ray • Angle of incidence, angle of refraction angle of emergence

	• To study the effect on intensity of light emerging through different colored transparent sheets using an LDR • Refractive index • Oblique incidence of light, Snell's law • Refraction through a parallel sided slab • Lateral displacement, • factors affecting lateral displacement • To observe refraction and lateral displacement of a beam of light incident obliquely on a glass slab • Formation of image in a glass slab
Module 4	• Special effects due to refraction • Real and apparent depth • To determine the refractive index of a liquid using travelling microscope • Total internal reflection • Optical fibers and other applications
Module 5	• Refraction through a prism • Deviation of light -angle of deviation • Angle of minimum deviation • Expression relating refractive index for material of the prism and angle of minimum deviation • To determine the angle of minimum deviation for given prism by plotting a graph between angle of incidence and angle of deviation • Dispersion, spectrum
Module 6	• Refraction at spherical surfaces • Radius of curvature • Refraction by a lens • Foci, focal plane, focal length, optical center, principal axis • Formation of images real and virtual • Lens maker's formula • Lens formula and magnification • Sign convention

	• Application of lens formula • Power of lens • Combination of thin lenses in contact

Module 7A and 7B	• To study the nature and size of image formed by a
	    ○ convex lens
	    ○ concave mirror using a candle and a screen
	• To determine the focal length of convex lens by plotting graphs between u and v, between 1/u and 1/v
	• To determine the focal length of a convex mirror using a convex lens
	• To find the focal length of a concave lens using a convex lens
	• To find the refractive index of a liquid by using a convex lens and a plane mirror

Module 8	• Scattering of light – • Blue color of sky • Reddish appearance of the sun at sunrise and sunset • Dust haze
Module 9	• Optical instruments • Human eye • Microscope • Astronomical telescopes reflecting and refracting • Magnification • Making your own telescope
Module 10	• Wave optics • Wave front • Huygens's principle shapes of wave front • Plane wave front • Refraction and reflection of plane wavefront using Huygens's principle • Verification of Laws of refraction and reflection of light using Huygens's principle
Module 11	• Superposition of waves • Coherent and incoherent addition of waves

Module 12	• Interference of light • Young's double slit experiment • Expression for fringe width • Graphical representation of intensity of fringes • Effect on interference fringes in double slit experiment • Black and white or colored fringes
Module 13	• Diffraction • Diffraction at a single slit • Width of the central maxima • Comparison of fringes in young's experiment and those in diffraction from a single slit
Module 14	• Diffraction in real life • Seeing the single slit diffraction pattern • Resolving power of optical instruments • Validity of ray optics • Fresnel distance
Module 15	• Polarisation • To observe polarization of light using two polaroid • Plane polarised light • Polariser analyser Malus law • Brewster/s law • Polarisation due to scattering • Uses of plane polarised light and polaroids

Words You Must Know

Let us remember the words and the concepts we have been using in the study of this module:

- **Light:** Light is a form of energy which gives the sensation of vision when it falls on the retina of the eye.
- **Ray of light:** The straight line path along which light travels is called a ray of light. Light rays start from each point of a source and travel along a straight line until they strike an object or a surface separating two media.
- **Beam of light:** A group of rays of light is called a beam of light.

- **Parallel beam of light:** If all the rays of light in the group are parallel to each other then the beam is said to be a parallel beam of light.
- **Converging beam of light:** If the rays of light in the group come closer to each other i.e. converge to a point, then the beam is said to be a converging beam of light.
- **Diverging beam of light:** If the rays of light in the group move away from each other i.e. diverge then the beam is said to be a diverging beam of light.
- **Transparent medium:** A medium through which light can pass freely over a large distance is called a transparent medium. Glass and still water are some examples of transparent objects
- **Opaque medium:** A medium through which light cannot pass is called an opaque medium. Wood and metals are some examples of opaque objects.

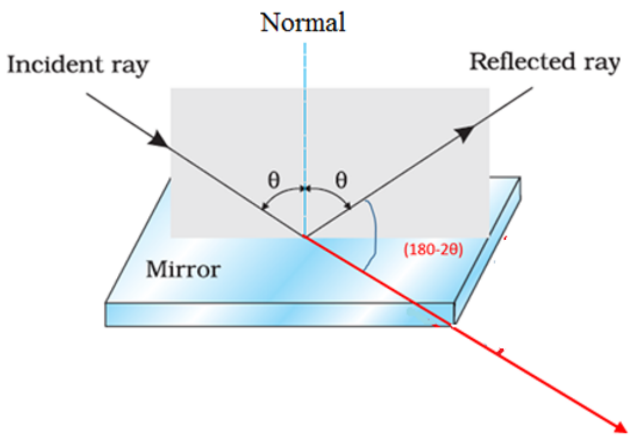
Introduction

Nature has endowed the human eye (retina) with the sensitivity to detect electromagnetic waves within a small range of the electromagnetic spectrum.

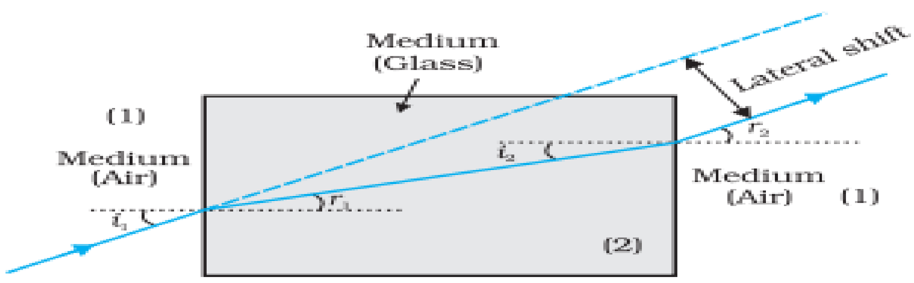
- Electromagnetic radiation belonging to this region of the spectrum (wavelength of about 400 nm to 750 nm) is called light.
- It is mainly through light and the sense of vision that we know and interpret the world around us. There are two things that we can intuitively mention about light from common experience.
- Light travels with enormous speed. Its presently accepted value in vacuum is $c = 2.99792458 \times 10^8$ m s^{-1}. For many purposes, it suffices to take $c = 3 \times 10^8$ m s^{-1}. The speed of light in vacuum is the highest speed attainable in nature.
- It travels in a straight line, which is ideal for a macro-picture.
- We have considered the phenomena of reflection, refraction and dispersion of light, using the ray picture of light. Using the basic laws of reflection and refraction, we studied the image formation by plane and spherical reflecting and refracting surfaces.
- Light rays always follow the basic laws of reflection and refraction at the point of incidence irrespective of the nature of the surface. Regular reflection created images in mirrors (polished smooth surfaces). We learnt about diffused reflection from a rough surface, which did not produce sharp images of bright objects.
- When a beam of light encounters a transparent medium, a part of light gets reflected back into the first medium while the rest enters the other. Light travels with a different speed in the second medium.

- In the second medium part of the incident light is absorbed and some transmitted through the medium. This phenomenon gives rise to terms transparent, translucent and opaque. For an opaque object there is only reflection and absorption.
- You will also recall that the intensity of reflected, transmitted light is less than the incident light intensity.
- Both reflection and refraction change the path of light. From the diagrams below we can see that the deviation would depend upon the angle of incidence and nature of the medium in which light travels.

Some pictorial recall

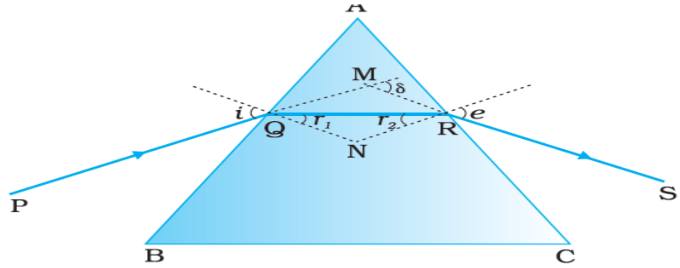


Deviation of light rays after reflection



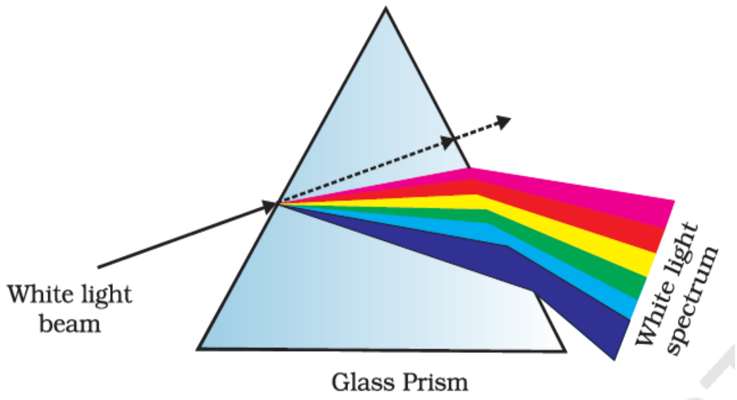
Lateral shift of a ray refracted through a parallel-sided slab

Or



Notice the change in the direction of the incident rays

We assumed that the medium (transparent or polished) was rigid and homogenous.
All gaseous and fluid mediums are non-rigid and they may or may not be homogeneous.
Also polychromatic light splits up on refraction as the refractive index for different colours of light is different



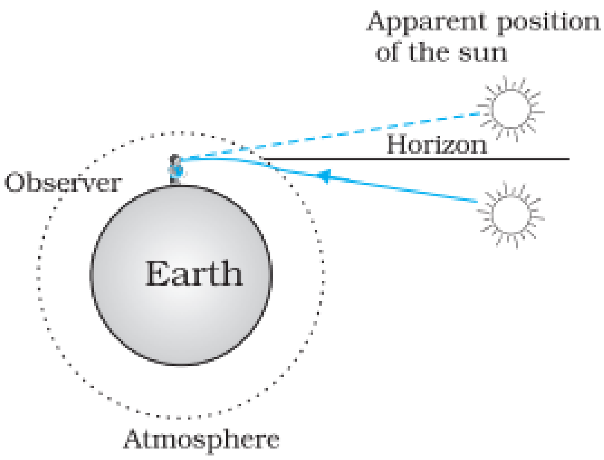
Refraction Through Atmosphere

The refraction of sunlight through the atmosphere is responsible for many interesting phenomena.

For example,

- The sun is visible a little before the actual sunrise and until a little after the actual sunset due to refraction of light through the atmosphere
  By actual sunrise we mean the actual crossing of the horizon by the sun. Figure shows the actual and apparent positions of the sun with respect to the horizon. The figure is highly exaggerated to show the effect.
  The refractive index of air with respect to vacuum is 1.00029.
  Due to this, the apparent shift in the direction of the sun is by about half a degree and the corresponding time difference between actual sunset and apparent sunset is about 2 minutes

https://hi.wikipedia.org/wiki/%E0%A4%9A%E0%A4%BF%E0%A4%A4%E0%A5%8D%E0%A4%B0:Sunrise_from_Kausani,_Almora,_Uttarakhand,_India.jpg



- The apparent flattening (oval shape) of the sun at sunset and sunrise is also due to the same phenomenon.

Example

The earth takes 24 h to rotate once about its axis. How much time does the sun take to shift by 1° when viewed from the earth?

Solution

Time taken for 360° shift = 24 h Time taken for 1° shift = 24/360 h = 4 min.

Sun And Sunlight

The Sun is a star, emitting electromagnetic radiations continuously. The visible component is often referred to as sunlight. The wavelength band includes infra-red, ultraviolet radiations as well. Common sights are the sunset, sunrise and the beautiful blue sky during the day.

https://www.maxpixel.net/Yellow-Sunlight-Color-Red-Orange-Glow-Sunset-652225

https://pxhere.com/en/photo/834040

The different colours of objects around us, the shades of the sky, the sun itself are a result of sunlight. After all, at night an unlit room cannot show any objects let alone the colours of objects.

It has been known for a long time that when a narrow beam of sunlight, usually called white light, is incident on a glass prism, the emergent light is seen to be consisting of several colours.

There is actually a continuous variation of colour, but broadly the different component colours that appear in sequence are: violet, indigo, blue, green, yellow, orange and red (given by the acronym VIBGYOR). The red light bends the least, while the violet light bends the most. **Atmosphere.**

Atmosphere has two basic qualities that make the refraction so interesting

- The atmosphere is not rigid.
- The atmosphere is not homogeneous.

Stars twinkle because of turbulence in the atmosphere of the earth. As the atmosphere churns, the light from the star is refracted in different directions. This causes the star's image to change slightly in brightness and position. Stars closer to the horizon will appear to twinkle more than other stars. This is because light travels a longer distance hence more refraction occurs.

How Sunlight Reaches The Earth?

- Sunlight travels at the speed of light.
- Light emitted from the surface of the Sun need to travel across the vacuum of space to reach our eyes.

- It takes sunlight an average of 8 minutes and 20 seconds to travel from the Sun to the Earth.
- Sunlight gives us light and heat.
- The actual brightness of sunlight that would be observed at the surface depends also on the presence and composition of an atmosphere.
- All parts of the earth do not receive the same sunlight; this is because the axis of the earth is inclined to the plane containing the orbit around the sun.
- Colour is associated with the wavelength of light.
- In the visible spectrum, red light is at the long wavelength end (~700 nm) while the violet light is at the short wavelength end (~ 400 nm).
- Dispersion takes place because the refractive index of medium for different wavelengths (colours) is different.
- The bending of the red component of white light is least while it is most for the violet.
- Equivalently, red light travels faster than violet light in a glass prism.
- Thick lenses could be assumed to be made of many prisms; therefore, thick lenses show chromatic aberration due to dispersion of light.
- In vacuum the speed of light is independent of wavelength.

Vacuum (or air approximately) is a non-dispersive medium in which all colours travel with the same speed, a glass prism is a dispersive medium

- Sunlight reaches us in the form of white light and not as its components.
- Objects reflect, absorb or transmit different colours depending upon the material they are made up of.
- The solar radiation varies with the angle of the sun above the horizon, with longer sunlight duration at high latitudes during summer, varying to no sunlight at all in winter near the pertinent pole.
- When the direct radiation is not blocked by clouds, and it is sunshine, all objects on the earth absorb heat energy from the electromagnetic radiation.
- We do not see the rays from the sun but large objects on which sunlight falls are illuminated.

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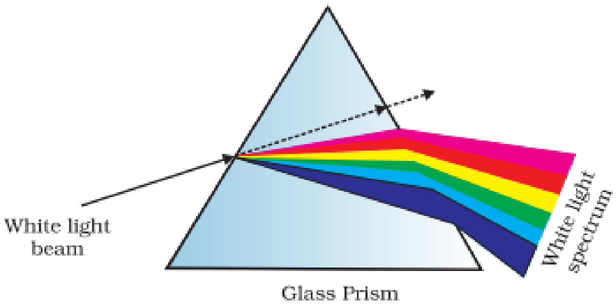
- The wavelength of light is very small compared to the size of ordinary objects that we encounter commonly (generally of the order of a few cm or larger).

Dispersion



Dispersion of sunlight or white light on passing through a glass prism

The phenomenon of splitting of light into its component colours is known as dispersion. The pattern of colour components of light is called the spectrum of light.

Colours of Objects

Visible light is made up of lights of many wavelengths. Each such wavelength has a particular colour. The colour of objects we see is a result of wavelengths which are reflected back to our eyes.

Objects appear of different colours because they absorb some colours (wavelengths) and reflect or transmit other colours. The colours we see correspond to wavelengths that are reflected or transmitted.

For example, a blue shirt looks blue because the dye molecules in the fabric have absorbed the wavelengths of light from the red end of the spectrum. Blue light is the only light that is reflected from the shirt. If only red light is shone onto a blue shirt, the shirt would appear black, because the red would be absorbed and there would be no blue light to be reflected. You may experience this effect in light from neon signs or yellow sodium street lights.

White objects appear white because they reflect all colours. Black objects absorb all colours so no light is reflected.

Some Natural Phenomena Due To Sunlight

https://cdn.pixabay.com/photo/2017/08/13/19/22/west-2638294_960_720.jpg

http://www.publicdomainpictures.net/pictures/30000/velka/clouds-1333454511tPj.jpg

The interplay of light with things around us gives rise to several beautiful phenomena. The spectacle of colour that we see around us all the time is possible only due to sunlight.

The blue of the sky, white clouds, the red hue at sunrise and sunset, the rainbow, the brilliant colours of some pearls, shells and wings of birds are just a few of the natural wonders we are used to.

Rainbow

https://cdn.pixabay.com/photo/2014/07/09/12/55/rainbow-388201_960_720.jpg

One of nature's most splendid masterpieces is the rainbow. A rainbow is an excellent demonstration of the dispersion of light and one more piece of evidence that visible light is composed of a spectrum of wavelengths, each associated with a distinct colour.

To view a rainbow;

- The sun must 'come out' after some rainfall.
- your back must be to the sun .
- Look at an approximately 40^0 angle above the ground into a region of the atmosphere which has suspended droplets of water or even a light mist.

Each individual droplet of water, acts as a tiny prism, disperses the light as well as reflects the light back to your eye. As you see into the sky, wavelengths of light associated with a specific colour arrive at your eye from the collection of droplets. The net effect of the vast array of droplets is that a circular arc of ROYGBIV is seen across the sky.

But just exactly how do the droplets of water disperse and reflect the light?

And why does the pattern always appear as ROYGBIV from top to bottom?

The rainbow is an example of the dispersion of sunlight by the water drops in the atmosphere. This is a phenomenon due to combined effect of

- dispersion,

- refraction and
- reflection of sunlight by spherical water droplets of rain.

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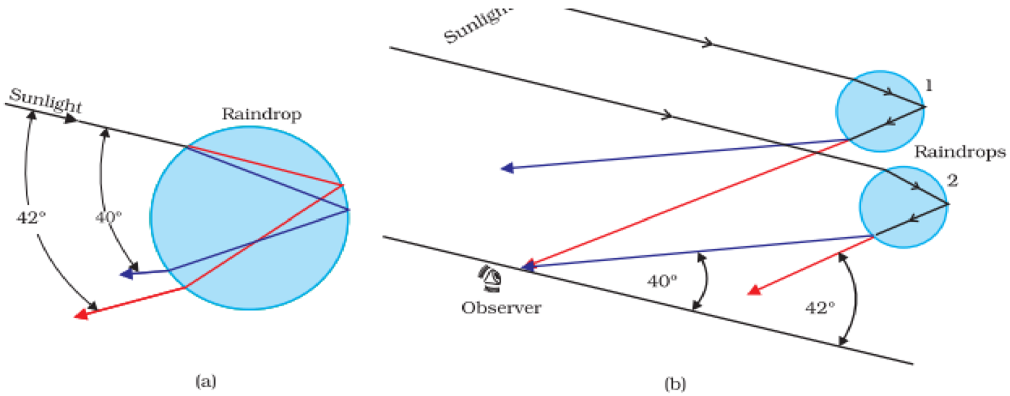
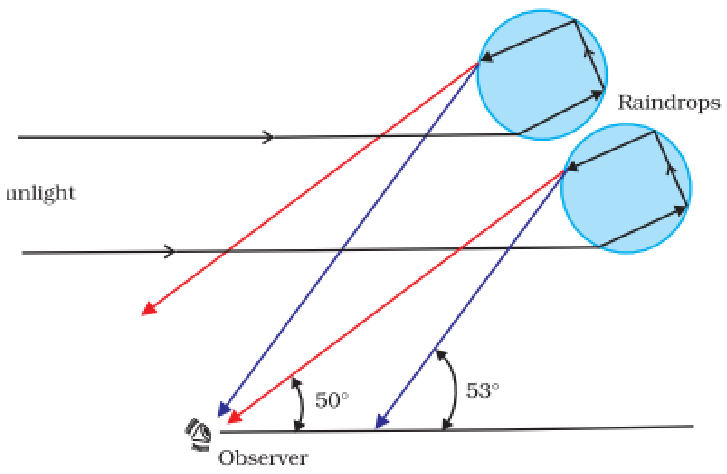
In order to understand the formation of rainbows, consider Figure (a). Sunlight is first refracted as it enters a raindrop, which causes the different wavelengths (colours) of white light to get separated out, or dispersed.

Longer wavelengths of light (red) are bent the least while the shorter wavelengths (violet) are bent the most. Next, these component rays strike





(c)

- The sun rays incident on a water drop get refracted twice and reflected internally by a drop;
- Enlarge view of internal reflection and refraction of a ray of light inside a drop forms primary rainbow; and
- Secondary rainbow is formed by rays undergoing internal reflection twice inside the drop. The inner surface of the water drops and gets internally reflected if the angle between the refracted ray and normal to the drop surface is greater than the critical angle (48º, in this case).

The reflected light is refracted again as it comes out of the drop as shown in the figure. It is found that the violet light emerges at an angle of 40º related to the incoming sunlight and red light emerges at an angle of 42º. For other colours, angles lie in between these two values.

Figure (b) explains the formation of the primary rainbow.

There are a multitude of paths by which the original ray can pass through a droplet and subsequently angle towards the ground. Some of the paths are dependent upon which part of the droplet the incident rays come in contact with.

Other paths are dependent upon the location of the sun in the sky and the subsequent trajectory of the incoming rays towards the droplet. Yet the greatest concentration of outgoing rays is found at these 40-42-degree angles of deviation.

At these angles, the dispersed light is bright enough to result in a rainbow display in the sky.

We see that red light from drop 1 and violet light from drop 2 reach the observer's eye. The violet, from drop 1, and red light, from drop 2, is directed at levels above or below the observer.

Thus the observer sees a rainbow with red colour on the top and violet on the bottom. Thus, the primary rainbow is a result of a three-step process, that is, refraction, reflection and refraction.

When light rays undergo two internal reflections inside a raindrop, instead of one as in the primary rainbow, a secondary rainbow is formed as shown in Fig. (c).

Intensity of the two rainbows

It is due to a four-step process.

The intensity of light is reduced at the second reflection and hence the secondary rainbow is fainter than the primary rainbow. Further, the order of the colours is reversed in it as is clear from Fig(c).

https://en.wikipedia.org/wiki/Rainbow

Scattering of Light

One may think of scattering of light as a change in the original straight line direction of propagation. This change can be due to a variety of causes. We generally consider 'scattering' as the phenomenon associated with the effect of tiny particles or irregularities present in the 'transmitting medium' in the path of light rays.

- **Elastic and inelastic scattering**

  The scattering of a ray of light, ordinarily, does not cause any change in wavelength of the incident light .We refer to such scattering as elastic scattering and normally refer to this type only.

  Under special conditions, scattering can cause a change in wavelength of incident light. Such type of scattering is known as 'inelastic scattering'.

  The phenomenon of **Compton scattering** and **Raman scattering** are examples of such inelastic scattering.

- **Diffused Reflection of Light**

  The process of a large number of randomly distributed and oriented, scattering centres (irregularities on the surface or randomly distributed particles) result in an almost uniformly distributed light in different directions. We call such scatterings, diffused reflection. It is such diffused reflected light that usually enables us to see/observe different objects. During the day, the rays of light from the sun are not visible, but the diffused light in the atmosphere makes us see objects.

Any place from which sunlight can be kept away will be dark and objects in such an environment will not be visible.

- **Different forms of Scattering**

  Quite often the scattering of light, due to its propagation through a material medium, is dependent on the characteristics or intrinsic properties of that material medium. The extent of such scattering can also depend on the wavelength of incident light.

  We refer to such scattering as 'material scattering'. It is such scattering whose effects are seen in daily life.

  The scattering of radio waves by the ionosphere and the scattering of sunlight by the particles /molecules of the atmosphere are examples of material scattering.The scattering of sunlight by atmospheric particles /molecules is generally in accordance with the law of scattering given by Rayleigh.The characteristic feature of Rayleigh scattering, as we know, is its 'inverse fourth power law'. As per this law the scattering is inversely proportional to the fourth power of the wavelength of incident light.

Amount of scattering $\propto \frac{1}{\lambda^4}$

Light of shorter wavelengths is scattered much more than light of longer wavelengths

We use Rayleigh's law to give a reasonably simple explanation of

- natural phenomenon like the blue colour of the sky, the reddish appearance, near the horizon around sunrise and sunset, and the general yellowish tone of the sun
- variation in colour of the sky at different times of the day.
- the use of red colour as warning signals or stoppage signals at road crossings

As sunlight propagates through the earth's atmosphere, it gets scattered (changes its direction) by the atmospheric particles.

Rayleigh's scattering is most prominently observed in gases, it is attributed to scattering by atoms or molecules or very small particles.

The bluish colour predominates in a clear sky. This is because blue colour has a shorter wavelength than red colour and is scattered much more strongly.

In fact, violet gets scattered even more than blue, having a shorter wavelength. But since our eyes are more sensitive to blue than violet, we see the sky blue.

Or

We can say we see the sky, as having its special blue tone because of combined effects of the scattered short wavelengths towards the blue end of the visible spectrum

Large particles like dust and water droplets present in the atmosphere behave differently.

The relevant quantity here is the relative size of the wavelength of light λ, and the scattered (of typical size, say, a)

- For a << λ, one has Rayleigh scattering which is proportional to $1/\lambda^4$.
- For a >> λ, i.e., large scattering objects (for example, raindrops, large dust or ice particles) this is not true; all wavelengths are scattered nearly equally.

Rayleigh's scattering is most prominently observed in gases, it is attributed to scattering by the atoms or molecules of the gas/air. It takes place from particles whose size is smaller than wavelength of light. It is prominent for particles of air whose refractive index is quite close to one (the refractive index of vacuum).

Passage of Sunlight Through The Atmosphere

When sunlight passes through the atmosphere it undergoes scattering from the atoms/ molecules in air as well as from the other particles suspended in the atmosphere. The extent and size of these other particles can vary with the overall atmospheric condition and pollution.

The atoms/ molecules of air, particles smaller than the wavelength of light cause elastic scattering in accordance with Rayleigh's scattering.

Thus on a clear unpolluted day the sky is blue during the day, the reddish colour at sunrise and sunset is a beautiful sight. We can also understand the yellowish colour of the sun during the day time.

On a dusty polluted day, there are relatively large particles in the lower atmosphere. The scattering from these can still be elastic but it may not be in accordance with Rayleigh's law.

- The scattering mechanism, corresponding to scattering by large particles, or molecules having dimensions larger than wavelengths of light known as Debye or Mie scattering.
- Unlike Rayleigh law, this type of scattering is not very much dependent on wavelength of light.
- In this the shape of the scattering particle is also important, for spherical particles. The scattering is roughly proportional to the diameter of the particle,
- We can associate the colour of smoke, fog etc to this.

Why are Clouds white?

Clouds are white because the light coming from the sun is white. As light passes through a cloud, it interacts with the water droplets, which are much bigger than the atmospheric particles that exist in the sky.

Using Rayleigh's criterion for scattering

Thus, clouds which have droplets of water with $a \gg \lambda$ are generally white.

When sunlight reaches an atmospheric particle in the sky, blue light is scattered away more strongly than other colours. But in a cloud, sunlight is scattered by much larger water droplets. These scatter all colours almost equally meaning that the sunlight continues to remain white and so making the clouds appear white against the background of the blue sky.

Why are clouds sometimes grey?

Cloud bases are often grey as a result of the same scattering that makes them white. When light is scattered in a cloud it usually is sent back upwards, or out to the sides of the cloud, making the tops and sides of the cloud whiter than the base which receives less light.

This is more prominent in rain clouds because the cloud droplets are bigger. They scatter more light, meaning even less light from the sun reaches the bottom of the cloud giving rain clouds their dark (grey) appearance.

Because the tops of clouds have a constant source of white light, they are always white!

If you are on a plane, look out of the window when you are above the clouds,

https://www.maxpixel.net/Flight-View-Clouds-Sky-Plane-Formations-1394162

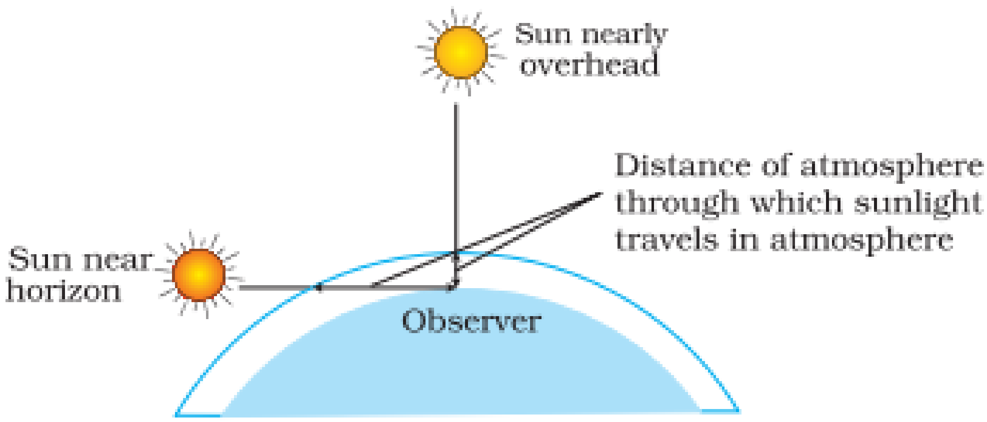
At sunrise or sunset, clouds can take on a red or orange colour.

This is because during sunrise and sunset, the sun is closer to the horizon and so light has to travel through more of the atmosphere. As a result more of the blue light is scattered and deflected away allowing more red and yellow light to reach the observer on the earth

Reddish Appearance Of The Sky And The Sun At Sunrise And Sunset

At sunset or sunrise, the sun's rays have to pass through a larger distance in the atmosphere. Most of the blue and other shorter wavelengths are removed by scattering. The least scattered red light reaches our eyes.

Therefore, the sun looks reddish. This explains the reddish appearance of the sun as well as the full moon, when they are near the horizon.



Sunlight travels through a longer distance in the atmosphere at sunset and sunrise.

Think About These

- Colour of space as observed by astronauts is black
- We cannot see well at night
- The Color of the sun as seen by an astronaut is white.
- Colour of our dress may appear different from the indifferent coloured artificial lights.

Summary

- Sunlight is polychromatic made up of seven colours
- Each colour light has a definite wavelength

- All colours travel with same speed in vacuum
- Sun light follows laws of Reflection and refraction
- Dispersion of light is due to the dissimilar speed of different light in a medium.
- Sunlight reaches an observer on the earth after passing through the atmosphere. The atmosphere is not rigid and not homogeneous
- The blue colour of sky is due to the almost ten times more scattering of blue end wavelengths of the incident sunlight by its atoms and molecules off the atmosphere
- The reddish appearance of the sun at sun set and sun rise is due to relatively least scattering of red end wavelengths of incident sunlight during its passage through the 'maximum length of the atmosphere' when the sun is near the horizon
- The yellowish tone of the sun –for most of the daytime –can be explained as a little more scattering of blue end wavelengths, when the sunlight reaches us by passing through a relatively smaller length of the atmosphere.
- The white scattered light seen in clouds and fogs may be roughly understood as due to Mie scattering, this is wavelength independent. When scattering is off large particles, all the wavelengths are scattered equally, and we get an almost whitish appearance. The extent of scattering and absorption also depends upon the shape and nature of the scattering particles. S considerable absorption may lead to a hazy appearance associated with dust haze and smog conditions