Chapter -7

Human Eye and Colourful World

SYNOPSIS

The human eye functions on the principle of sensation of vision. We see objects because of the light scattered from them falls on the eye. The eye has a lens in its structure. This eye lens forms a real and inverted image of an object on the retina. The distance between the lens and retina is about 2.5 cm i.e., for any position of object in front of the eye the image distance is fixed and about 2.5cm. The maximum and minimum focal lengths of eye lenses are 2.5 cm and 2.27 cm respectively.

Some times the eye may gradually lose its ability for accommodation. In such conditions the person cannot see an object clearly and comfortably. The vision becomes blurred due to defects of the eye lens. There are mainly three common defects of vision. They are i) Myopia ii) Hypermetropia iii) Presbyopia

Myopia is also called near sightedness. A person suffering myopia cannot see objects at long distance but can see nearby objects clearly. To correct one's myopia by bi-concave lens.

Hypermetropia is also known as "far sightedness". A person with hypermetropia can see distant object clearly but cannot see objects at near distance. Biconvex lens is used to correct the defect of hypermetropia.

Presbyopia is vision defect. This happens due to gradual weakening of ciliary muscles. To correct we need bi-focal lenses which are formed using both concave and convex lenses.

The refractive index of the material of the prism can be calculated by the formula

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\frac{A}{2}}$$

The splitting of white light into different colors (VIBGYOR) is called dispersion. Rainbow formation is the example of dispersion of light.

Sun appears red in colour during sunrise and sunset due to scattering of light. The blue colour of sky is also due to scattering of light.

2 Mark Questions

1.Light wave length (λ_1) enters a medium with refractive index n_2 from medium with refractive index n_1. Then what is the wave length of light to second medium? (AS_1)

Sol. Wave length in first medium $=\lambda_1$

Wave length in second medium $=\lambda_2$

Refractive index of first medium $=n_1$

Refractive index of second medium$=n_2$

Light enters from first medium to second medium

$$\frac{v_1}{v_2}=\frac{\lambda_1}{\lambda_2}=\frac{n_2}{n_1}$$

2.Assertion: The refractive index of a prism depends only on the kind of glass of which it is made of and the color of light.

Reason: The refractive index of a prism depends on the refracting angle of the prism and on the angle of minimum direction (AS_2)

Sol: Both A and R are true and R is not the correct explanation of A

Refractive index (n) depends on nature of material and colour of light and also it is measured in terms of apex angle and deviation angle as follows

$$n=\frac{\sin(A+D)}{\sin\left(\frac{A}{2}\right)}$$

3. Assertion: Blue colour of sky appears due to scattering of light.

Reason: Blue color has shortest wavelength among all colors of white light. (AS_2)

A. Here A is true and R is false.

Sky appears blue due to scattering of light.

Among all colours, violet colour has shortest wave length, but blue is sensible to eyes in white light, so, sky appears as blue in colour.

4. Why does the sky sometimes appear white? (AS_7)

A. 1. When the atmosphere contains lot of dust particles that are larger than nitrogen and oxygen molecules, light of lower frequencies is also scattered strongly.

2. Due to this, sky sometimes wears whitish appearance.

3. After a heavy rain during which most of the dust particles are washed down, the sky takes back its blue colour.

5. Glass is known to be a transparent material. But ground glass is opaque and white in colour. Why? (AS_7)

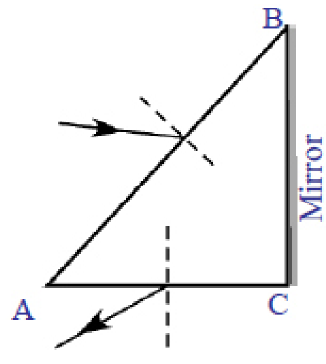
A. 1. Glass is general a transparent material because it transmits most of the light incident on it.

2. When glass is ground, its surface becomes rough due to microscopic unevenness.

3. When light is incident on such a rough surface, it is reflected in many different directions.

4. This type of reflection is known as diffuse reflection due to this ground glass opaque and white in color.

6. Incident ray in one of the face (AB) of a prism and emergent ray from the face are given in figure. Complete the ray diagram. (AS_5)



A. Here AB, AC are refracting surface and BC is reflecting surface. Incident ray enters into prism (denser medium) from air (rarer medium) so it bends towards normal.

Emergent ray comes into (rarer medium) air from prism (denser medium)

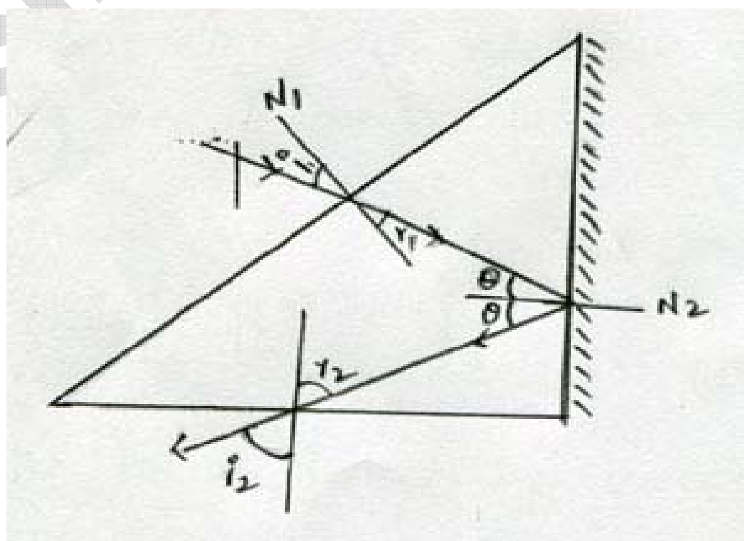
So, it bends away from normal

For mirror: angle of incidence= angle of reflection

N_1, N_2, N_3 are normal's i_1- angle of incidence

i_2- angle of emergence r_1, r_2- angle of refraction

-angle of incidence, reflection for the mirror



7. Eye is the only organ to visualize the colourful world around as this is possible due to accommodation of eye lens. Prepare a six line stanza explaining your wonderful feelings. (AS_6)

A. Oh! wonderful eyes

You help us to see behind skies

You show us the world bright

The depth of oceans

And the mountains height

Thank you nature for gifting me sight

8.How do you appreciate the working of ciliary muscle in the eye? (AS_6)

A. Ciliary muscle is a ring shaped smooth muscle in the middle layer of eye that control shape of the lens for viewing objects at varying distances.

1. It also regulates the flow of aqueous humor.

2. When they contracts, it pull itself forward and moves the central region towards the axis of the eye.

3. This causes the lens of eyes to become more spherical adapting to short range forces.

4. On other hand, relaxation of ciliary muscles causes flattering of lens increasing long range forces

9. A person is viewing an extended object. If a converging lens is placed in front of his eye, will he feel that the size of the object has increased? Why? (AS_7)

A. The image formed by convex lens depends on the position of object

i.e., 1.is the person feels that the size of objects has increased

2. He used the converging lens i.e., the convex lens and the image is an extended object.

3. The image is formed when the object is in between foci (f) and lens centre (p) of the lens.

4. Hence the size of image seems to be increased.

1 Mark Questions

1. If a write sheet of paper is strained with oil, the paper turns transparent. Why?

A. As paper is a white solid material and absorbent, it will absorb oil, so it becomes transparent until it dries. Until it dries, it can transmit the light which incident on it.

2. What is accommodation of eye lens?

A. The ability of eye lens to change its focal length with respective to ciliary muscles is known as accommodation of eye lens.

3. State the range of focal length of human eye lens for an adult.

A. 2.27cm-2.5cm

4. Define dispersion?

A. splitting of white light into colors, this phenomenon is known as dispersion.

5. in all colours in white light, white colour has minimum divination?

A. Red colour has minimum deviation

6. Can you guess the reason, why sun does not appear red during noon hours?

A. During noon hours, sun light travels less distance through the atmosphere then the morning and evening times. Therefore all the colors reaches without much scattering, thus the sun appear white at noon.

7. State function of optical nerve?

A. The optical nerve transmits visual information from retina to the brain.

8. Define scattering.

A. The process of absorption of light of certain frequency and re-emission in all possible directions with altered frequency by the atoms (molecules) of a substance is known as scattering.

9. State different types of defects of vision.

A. Mainly defects of vision are 3 types-

1. Myopia
2. Hypermetropia
3. Presbyopia

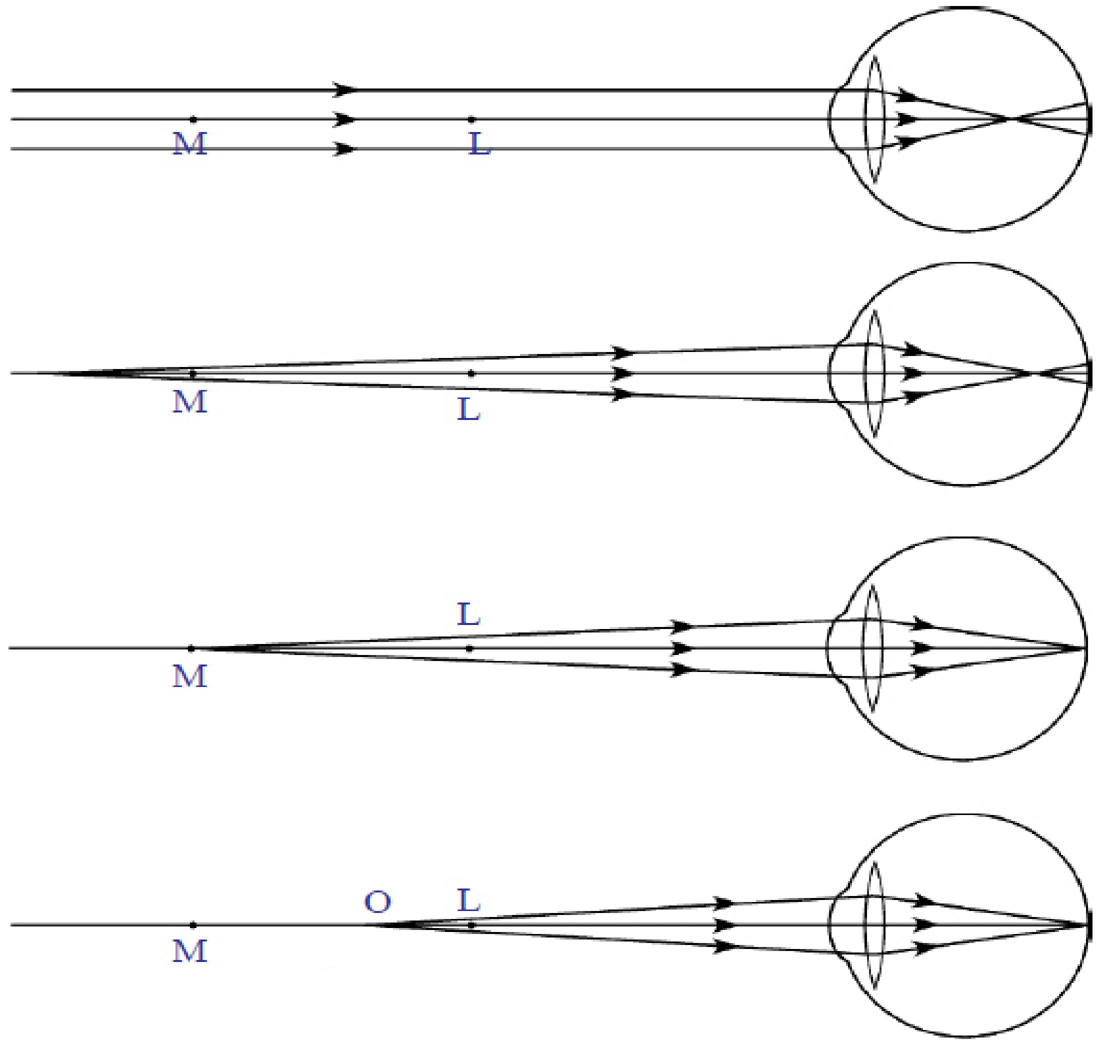
4 Mark Questions

1. How do you correct the eye defects myopia? (AS_1)

A. 1. The point of maximum distance at which the eye lens can form an image in the retina is called as far point.

2. The defeat in which people can't see objects beyond the far point is myopia (or) near sightedness.

3. The eye lens can form clear image on the retina when an object is placed between far point and point of least distance of distinct vision.



4. If we are able to bring the image of the object kept beyond far point, between far point and the point of least distance of distinct vision using a lens, this image acts as an object for the eye lens

5. This can be possible only when a concave lens is used.

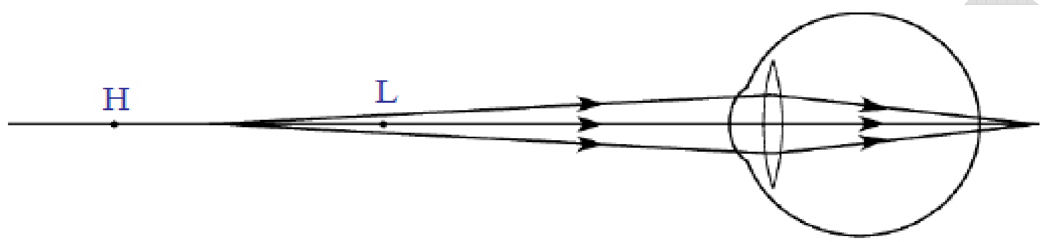
6. To correct one's myopia, we need to select a lens which forms an image at the far point for an object at infinity.

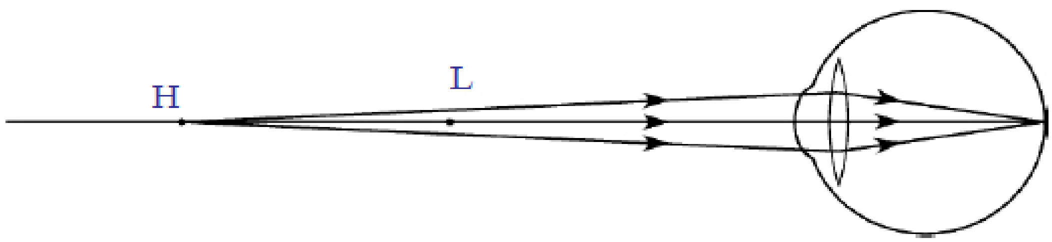
7. We need to select biconcave lens to correct this, with a focal length (f=-D)

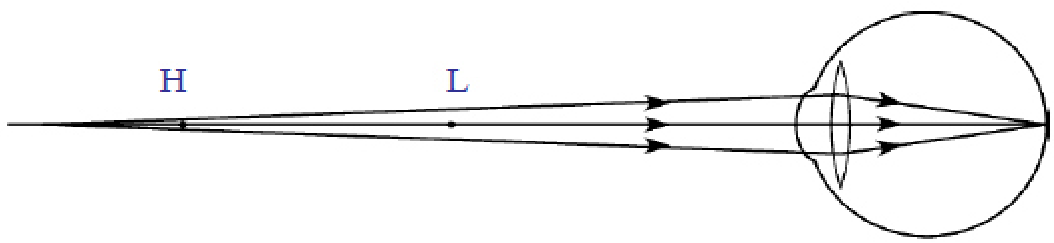
D-distance of far point (in cm)

2. Explain the correction of the eye defect hypermetropia?

A. 1. In the case of hypermetropia, the rays coming from a nearly object after refraction from the lens, form an image beyond retina.







2. Let the point of minimum distance at which the eye lens forms clear image on retina be known as near point.

3. The people with defect of hypermetropia cannot see objects placed between near point (H) and point of least distance of distinct vision (L)

4. Eye lens can form a clear image on the retina when any object is placed beyond near point.

5. To correct hypermetropia, we need to use an lens which forms an image beyond near point when the object is placed between near point (H) and least distance of

clear vision (L), so we need a double convex lens of focal length $f = \frac{25d}{d-25} cm$ where 'd' is distance of near point.

3. How do you find experimentally the refractive index of a prism? (AS_1)

A. **Aim:** Finding the refractive index of a prism

Materials required: Prism, piece of white chart of size 20X20cm, pencil, protractor, pins and scale.

Procedure:

1. Let us take a prism and place it on the white chart in such a way that the triangular base of the prism is on the chart.

2. Let us draw a line around the prism using a pencil having vertices P, Q and R and remove the prism.

3. Measure the angle between PQ and QR which gives the angle of prism (A).

4. Let us consider a light ray 'AB' incident on at M. Draw a normal at M.

5. Let us mark M on PQ and draw a perpendicular to PQ at M.

6. Let us mark an angle 30^0 and draw a line AB at 'M'.

7. Fix 2 pins vertically on the line AB.

8. Now let us look for the images of 2 pins through the prism on other side and fix another 2 pins say C and D.

9. Remove the prism and draw a line to PR which passes through C and D points. This line gives emergent ray.

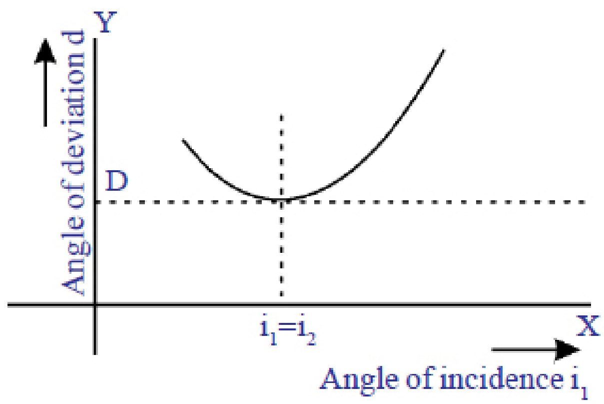
10. Draw a normal to 'PR' and measure the angle of emergence (i_2).

11. Now extend the both incident and emergent ray till they meet a point O.

12. Measure the angle between the extended 2 rays which give angle of deviation ($\angle d$) plot graph between i and d.

13. As the angle of incidence charges angle of deviation also charges

14. As the angle of incidence increases, angle of deviation decreases and attains a minimum value (Angle of minimum deviation) and further it increases with increasing in angle of incidence.



15. Now tabulate the reading of angle of incidence (i_1), angle of emergence (i_2) and angle of deviation (d)

Angle of incidence (i_1),	Angle of emergence (i_2)	Angle of deviation (d)

16. Angle of prism is A.

Angle of minimum deviation is D

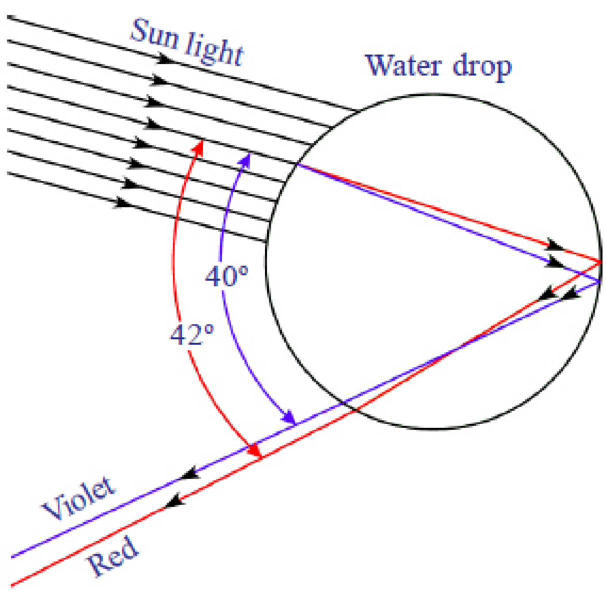
i.e., $\mu = \frac{\sin i}{\sin r} \Rightarrow \mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

4. Explain the formation of rainbow. (AS_1)

A. 1. The beautiful colours of the rainbow are due to dispersion of the sunlight by millions of tiny water droplets. Let us consider the case of an individual water droplet.

2. Observe the figure the rays of sunlight enters the drop near its top surface at this first refraction, the white light is dispersed into its spectrum of colors, violet being deviated the most and red the least.

3. Reaching the opposite side of the drop each colour is reflected back into the drop because of total internal reflection.



4. Arriving at the surface of the drop each colour is again refracted into air

5. At the second refraction, the angle between red and violet rays further increases when compared to the angle between those at first refraction.

6. We observe bright rainbow when the angle incoming and outgoing rays are near the maximum angle is 42^0.

5. Explain briefly the reason for the blue of the sky? (AS_1)

A. 1. Sky appears blue due to a phenomenon known as scattering of light, which may be defined as re emission of light by atoms or molecule in all directions with different frequency when compared to incident frequency

2. An atom will respond to incoming light only when the wave length is comparable to size of the atom. Majority of earth's atmosphere is composed of nitrogen and oxygen molecules

3. The atomic size of these molecules matches with wave length of violet and blue colour light so, these colours are scattered more giving a beautiful sight.

4. Even though violet colour undergoes maximum scattering, we see the sky to be blue because human eye is more sensitive to blue to be blue because human eye is more sensitive to blue colour than violet colour light

6. Explain 2 activities for the formation of artificial rainbow. (AS_1)

A. Activity 1:

1. Take a metal tray and fill it with water.

2. Place a mirror in the water such that it makes an angle to the water surface.

3. Now focus, white lights on the mirror though the water as shown in the figure.

4. Try to obtain colours on a white cardboard sheet kept above the water surface.

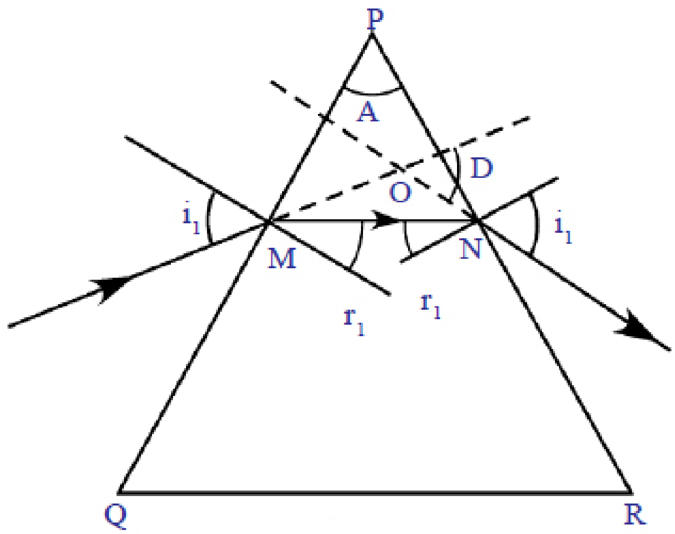
5. We can observe the seven colors of VIBGYOR on the cardboard sheet.

Activity 2:

1. Take a CD. Wipe it to make sure it is not dusty, so it will look better
2. Place it on a float surface, level side down under a light or in front of a window
3. Look at the CD, and the rainbow will be visible.
4. Hold the CD in between your fingers an move to see how the colours move

7. Derive an expression for the refractive index of the material of a prism (AS$_1$)

Description:



PQR –Glass triangular shaped prism

PQ, PR- refracting surfaces of prism

QR- Base of prism

A- Angle of prism (or) apex angle

M^1M – incident ray

N^1N- emergent ray

MN- refracted ray

d- Angle of deviation

Derivation

From triangle OMN

$d = i_1 - r_1 + i_2 - r_2$

$(i_1 + i_2)(r_1 - r_2) \longrightarrow (1)$

From Δ^{le} PMN

$A+90-r_1+90-r_2$________(2)

From (1) and (2) we have

$d=i_1+i_2-A$

$$d + A = i_1 + i_2 \longrightarrow (3)$$

This is the relation between angle of incidence, angle of emergence, angle of prism, angle of deviation.

From Snell's law, we known that $n_1 \sin i = n_2 \sin r$

Here n is the refractive index of the prism.

Using Snell's law at M

1. $\sin i_1 = n \sin r_1$________(4) ($\because n_1$ (air)$=1$)

Similarly at N

n. $\sin r_2 = 1 \sin i_2$________(5)

We known that at the angle of minimum deviation (D) the angle of incidence is equal to angle to angle of emergence is i.e., $i_1=i_2$

Observe the figure, you can notice that MN is parallels to base of prism (QR)

When $i_1 \neq i_2 = i$ angle of deviation (d) becomes angle of deviation (D)

Then (3) comes

$D+A=2i \Rightarrow i=\frac{D+A}{2}$

If $i_1=i_2 \Rightarrow r_1=r_2$

r_1+r_2__________ from(2)

$2r = A$

$r = \frac{A}{2}$

So, substituting r and i in (4)

$$\sin\left(\frac{D+A}{2}\right) = n\sin\left(\frac{A}{2}\right)$$

Formula for refractive index of the prism

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

For small angles $\sin\theta \approx \theta$

$$n = \frac{\left(\frac{D+A}{2}\right)}{\frac{A}{2}} = n = \frac{D+A}{A}$$

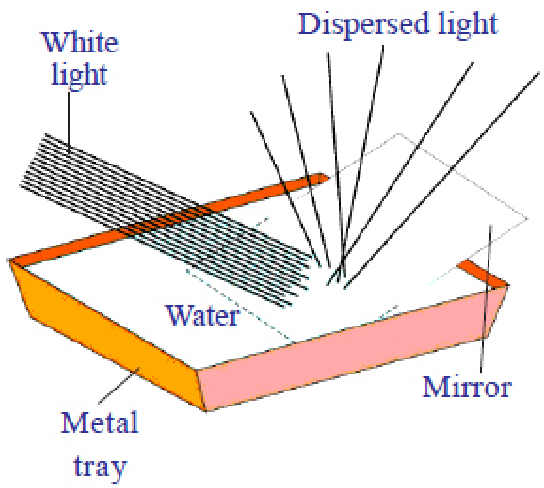
8. Suggest an experiment to produce a rainbow in your classroom and explain the procedure. (AS_3)

A. **Aim.** To produce rainbow-

Apparatus: tray, water, mirror

Procedure:

1. Take a metal tray and fill it with water.
2. Place a mirror in the water such that it makes an angle to the water surface.
3. Now focus the white light on the mirror.
4. Try to obtain colour on a white cardboard sheet kept above the water surface.
5. Note the names of the colors you could see in note book.
6. We know that the white light is splitting into certain different colour as rainbow.



9. Prism used in binoculars. Collects information why prisms are used in binoculars (AS_4)

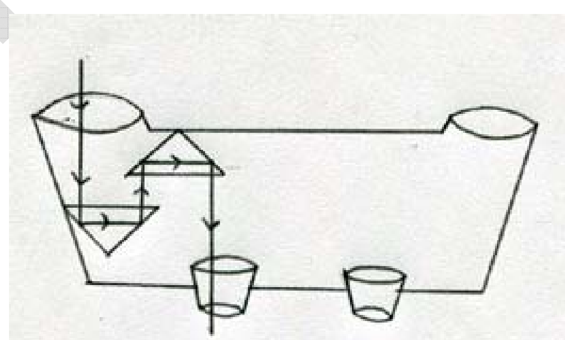
A. 1. If 2 telescopes are mounted parallel to each other so that an object can be seen by both the eyes simultaneously the arrangement is called binocular.

2. The length of each tube is reduced by using a set of totally reflecting prisms.

3. They provide intense, erect image free from lateral inversion.

f_0-focal length of objective

f_e- focal length eyepiece



4. Through a binocular we get 2 images of the same object from different angles at same time.

5. Their super position gives the perception of depth also with length and breadth.

6. Binocular vision gives proper 3D image.

7. By using total reflecting prisms there is no loss of intensity.

10. How do you appreciate the role of molecules in the atmosphere for the blue colour of sky? (AS_6)

A. 1.Blue colour of the sky is because of scattering of sunlight by molecules of air

2. Out of all the visible frequencies violet is scattered most followed by blue, green, yellow, orange and red.

3. A though violet is scattered more than blue we see the sky to be blue in colour because human eye is more sensitive to blue colour than violet.

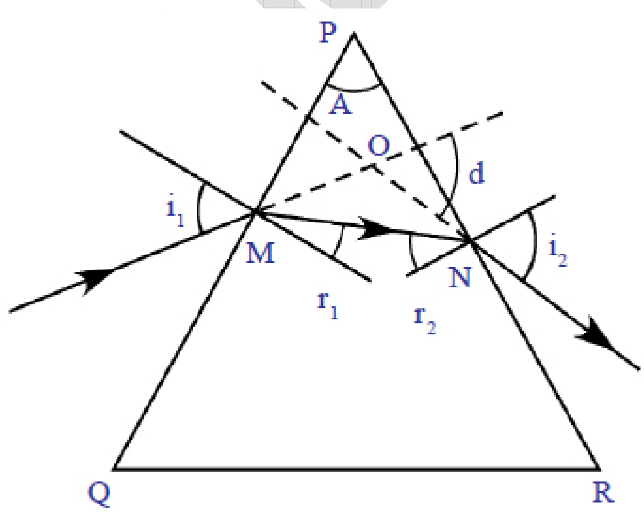
4. Nitrogen and oxygen molecules make up large part of the atmosphere.

5. When sunlight falls on them they absorb certain frequencies and re-emit the light in all directions with different frequencies.

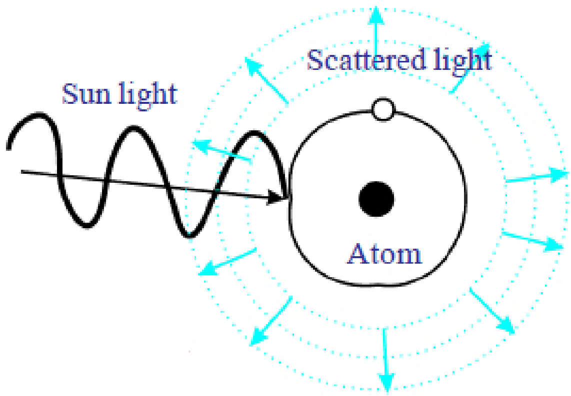
6. The amount of scattering is proportional to frequency of light.

5 Mark Questions

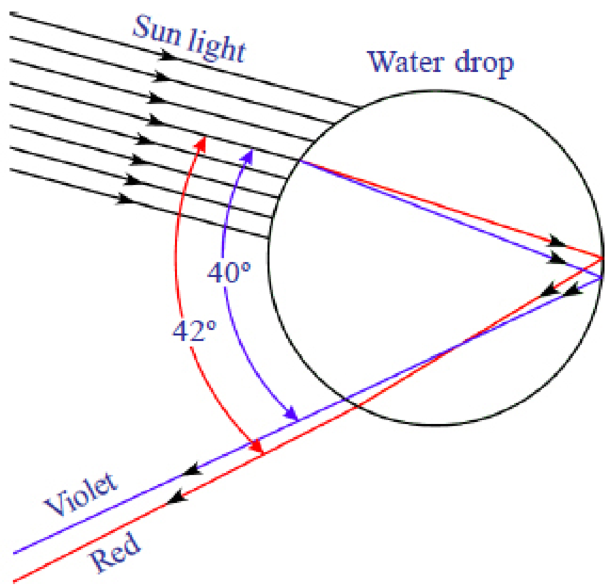
1. Refraction of light in prism



2. **Scattering of sunlight by an atom**



3. **Dispersion of light in a water drop**



Problems

1. Light ray falls on one of the faces of a prism at an angle 40^0 so that it suffers angle of minimum deviation of 30^0. Find the angle of prism and angle of refraction at a given surface. (AS_1)

A. Angle of incidence $i=40^0$

Angle of minimum deviation $D=30^0$

Let angle of prism =A

At angle of minimum deviation

A + D=2i

A + 30= 2(40)

A=80-30

$=50^0$

Angle of prism $=50^0$

Refractive index of prism n= $n=\frac{\sin\frac{A+D}{2}}{Sin\frac{A}{2}}$

$$=\frac{\sin\frac{50+30}{2}}{Sin\frac{40}{25}}$$

$$\frac{\sin 40}{\sin 25}$$

n=1.5209

Using Snell's law

$$\frac{\sin i}{\sin r} = n$$

$$\frac{\sin 40}{sinr} = n$$

$$sinr = \frac{\sin 40}{n} = \frac{\sin 40}{1.5209}$$

$$r = \sin^{-1}\left[\frac{\sin 40}{1.5209}\right]$$

r=25.001°

Angle of refraction r= 25°

2. The focal length of a lens suggested to person with hypermetropia is 100 cm. Find the distance of near point and power of lens.

A. Focal length of lens =100cm

Power of lens p= $\frac{100}{f} = \frac{100}{100}$

1D

Power of lens p= 1 diptre

The focal length of lens f=$\frac{25d}{d-25}$

Where d is the nearest point

$$100 = \frac{25d}{d-25}$$

4d-100=d

3d=100

$$d = \frac{100}{3}$$

d= 33.3cm

Distance of near point =33.33cm

Fill in Blanks

1. The value of least distance of distant vision is about _________.
2. The distance between eye lens and retina is _____.
3. The minimum focal length of eye lens is about________.
4. The eye lens can change its focal length due to working if ___muscles.
5. The power of lens is one di ptre (ID) then focal length is ______.
6. Myopia is corrected by using ____lens.
7. Hypermetropia can be corrected by using _____lens.
8. In minimum deviation position of prism the angle of incidence is equal to angle of _________.
9. The splitting of white light into different colors (VIBGYOR) is called___.
10. During refraction of light, the character of light doesn't change is
11. Blue colour of sky is a result of ________.
12. ______are the receptors which identify colour.
13. ______ are the receptors which identify intensity of light.
14. A person suffering from hypermetropia cannot see the objects at__.
15. A person suffering from myopia cannot see the objects at _________.
16. When i_1=i_2 (angle of incidence =angle of emergence) then the angle of deviation becomes____.
17. Power of lens p=_________.
18. Limit of power is ________.
19. Refractive index of a medium depends on _______of light.
20. Refractive index of prism n=.

Key

1) 25cm 2) 2.5 cm 3) 2.5 cm 4) Ciliary muscles

5) 100cm 6) Biconcave 7) Biconvex 8) Emergence

9) Dispersion 10) Frequency 11) Dispersion 12) Rods

13. Cones 14) Near distance 15) Longer distance

16) Minimum (angle of minimum deviation) 17) $\frac{100}{(f)\, in\, cm}$

18) Dioptre 19. Wave length 20.) $\frac{\sin\frac{(A+D)}{2}}{\sin\left(\frac{A}{2}\right)}$

Multiple Choice Questions

1. The size of an object is perceived by an eye depends primarily on? [b]

(a) Actual size of object (b) Distance of the object from the eye

(c) Aperture of pupil (d) Size of image formed on retina

2. When objects at different distances are seen by eye, which of the following remain constant? [d]

(a) Focal length of lens (b) Object distance from eye lens

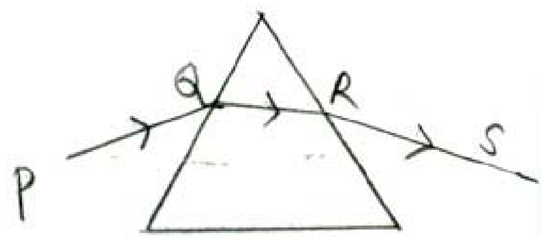
(c) The radii of curvature (d) Image distance of eye lens

3. During refraction, _______will not change. [b]

(a) Wave length (b) Frequency

(c) Speed of light (d) All the above

4.A ray of light falls on one of the lateral surface of an equilateral glass prism placed on a horizontal surface of a table as shown in figure for minimum deviation of ray, which of the following is true [b]



(a) PQ is horizontal (b) QR is horizontal

(c) RS is horizontal (d) Either PQ or RS horizontal

5. **Far point of person is 5m in order that he has normal vision what kind of spectacles should he use. [a]**

(a) Concave lens with focal length 5m (b) Concave lens with focal length 10m

(c) Concave lens with focal length 5m (d) Concave lens with focal length 2.5m

6. **The process of remission of absorbed light in all directions with different intensities by an atom or molecule is called? [a]**

(a) Scattering of light (b) Dispersion of light

(c) Reflection of light (d) Refraction of light

7. **A camera employs a ________lens to form ________ images. [b]**

(a) Divergent, real (b) Convergent, real

(c) Divergent, virtual (d) Convergent, virtual

8. The muscles of it control the __________. **(b)**

(a) Focal length of eye lens (b) Opening of pupil

(c) Shape of crystalline lens (d) Optic nerve

9. Rainbow is censed due to _____. **[c]**

(a) Reflection of sunlight from air

(b) Dispersion of light

(c) Refraction of light

(d) Scattering of light

10. The number of surfaces bounding a prism______. **[c]**

(a) 3 (b) 4 (c) 5 (d) 6

11. The sky looks blue and clear on sunny day because____. **[b]**

(a) Dispersion of light (b) scattering of light

(c) Reflection light (d) refraction of light

12. The power of accommodation of normal eye is? **[a]**

(a) 4D (b) 40D c) 44D (d) 400D

13. Natural example of dispersion of light is? **[c]**

(a) Scattering (b) blue colour of sky

(c) Rainbow (d) none of these

14. When the focal length of lens is 50cm, then power of lenses is _____. **[d]**

(a) 1D (b) 2D (c) 0.25D (d)0.5D

15. The wave lengths corresponding to violet, yellow, red lights - **[b]**

a) $\lambda_v > \lambda_y > \lambda_r$ (b) $\lambda_v < \lambda_y < \lambda_r$

(c) $\lambda_y < \lambda_v < \lambda_r$ (d) $\lambda_y < \lambda_r < \lambda_v$

Match the following

I. Group1 **Group 2**

Group1		Group 2
1. Myopia	[B]	A. Far sightedness
2. Retina	[D]	B. Near sightedness
3. Cornea	[C]	C. Thin membrane
4. Presbyopia	[E]	D. Light sensitive screen
5. Hypermetropia	[A]	E. Gradual weakening of ciliary muscles

II. Group1 **Group 2**

Group1		Group 2
1. Power	[E]	A. $n = \dfrac{\sin\dfrac{(A+D)}{2}}{\sin\dfrac{A}{2}}$
2. Refractive index prism	[A]	B. $V = \upsilon\lambda$
3. Snells law	[D]	C. $i_1 = i_2$
4. Condition of minimum Deviation	[C]	D. $n = \dfrac{\sin i}{\sin r}$
5. Velocity of light	[B]	E. $\dfrac{1}{(f)inm}$ or $\dfrac{100}{f.incm}$