Viva Voce for μ by Spectrometer

Q. 1. What is refraction, laws of refraction and refractive index? How refractive index vary with wavelengths?

Ans. A. The bending of the light-ray from its path in passing from one medium to the other medium is called 'refraction' of light. If the refracted ray bends towards the normal relative to the incident ray, then the second medium is said to be 'denser' than the first medium (Fig. 1a). But if the refracted ray bends away from the normal, then the second medium is said to be 'rarer' than the first medium (Fig.1b).

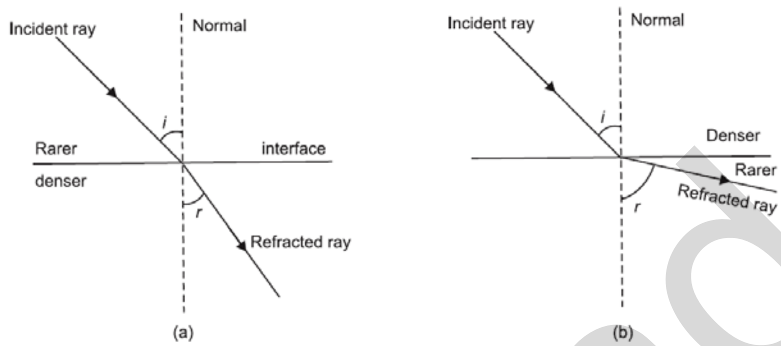


Fig.A1

B. The refraction of light takes place according to the following two laws known as the 'laws of refraction':

1. The incident ray, the refracted ray and the normal to the interface at the incident point all lie in the same plane.
2. For any two media and for light of a given colour (wavelength), the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

If the angle of incidence is i and the angle of refraction is r, then $\frac{\sin i}{\sin r} = constant$

C. The ratio of the sine of the angle of incidence to the sine of angle of refraction is constant of any two media, i.e.,

$n = \mu = \frac{\sin i}{\sin r}$; where μ is a constant known as refractive index.

D. According to Cauchy's relation, we know that, $\mu = A + \frac{B}{\lambda^2}$, here A and B are constants.

This relation indicates that Higher is the wavelength, smaller is the refractive index.

Q. 2. What is angle of minimum deviation?

Ans. The angle between incident and emergent ray (PQ and RS) for a prism is called as angle of deviation (FigA2). The angle of deviation is called as minimum angle of deviation when angle of emergence becomes equal to angle of incidence.

Note: For a given prism, the angle of deviation depends upon the angle of incidence of the light-ray falling on the prism. If a light-ray is allowed to fall on the prism at different angles of incidence (but not less than 30°) then for each angle of incidence the angle of deviation will be different. If we determine experimentally the angles of deviation corresponding to different angles of incidence and then plot i against δ, then we shall get a curve as shown in Fig. B2. It is seen from the curve that as the angle of incidence i increases, the angle of deviation first decreaes, becomes minimum for a particular angle of incidence and then again increases. Thus, for one, and only one particular angle of incidence the prism produces minimum deviation. The minimum angle of deviation is represented by δ_m. In the position of minimum deviation, the angle of incidence i and the angle of emergence i′ are equal and hence r=r′.

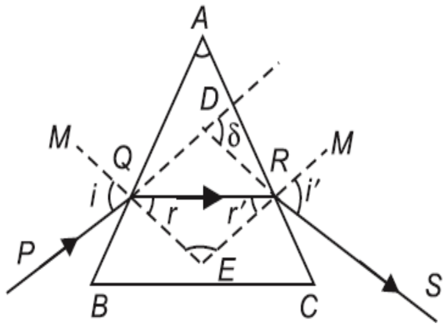


Fig.A2

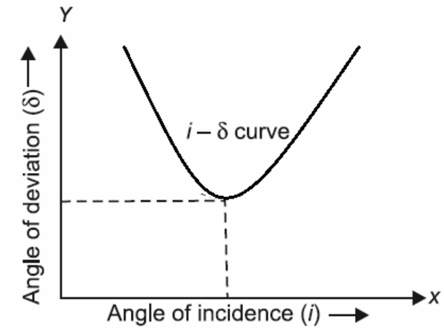


Fig.B2

Proof:

In $\Delta\, QDR$, we have

$$\delta = \angle DQR + \angle DRQ$$
$$= (i - r) + (i' - r')$$
$$= (i + i') - (r + r') \qquad \text{...(1)}$$

In the quadrilateral $AQER$, $\angle AQE$ and $\angle ARE$ are right angles. Hence the sum of the angles A and E is 180°.

$$A + E = 180^\circ$$

In $\Delta\, QER$ $\qquad r + r' + E = 180^\circ$

From these two equations, we have

$$\boxed{r + r' = A} \qquad \text{...(2)}$$

Substituting this value of $r + r'$ in Eq (1), we have

$$\delta = i + i' - A \qquad \text{...(3)}$$
$$i' = i,\ r' = r,\ \delta = \delta_m$$

Hence from the equations (2) and (3), we have

$$2r = A \text{ or } r = A/2$$

and $\qquad \delta_m = 2i - A \text{ or } i = (A + \delta_m)/2$

By Snell's law, $\qquad n = \dfrac{\sin i}{\sin r}$

Substituting the value of i and r, we get

$$n = \sin\left(\frac{A + \delta_m}{2}\right) \Big/ \sin\frac{A}{2}$$

Thus, knowing the angle of minimum deviation and the angle of prism, the refractive index of the material of the prism can be calculated.

If the prism is thin (i.e. its angle A is nearly 5° or less), δ_m will also be small and we can put.

$$\sin\frac{A + \delta_m}{2} = \frac{A + \delta_m}{2} \text{ and } \sin\frac{A}{2} = \frac{A}{2}$$

$$\therefore \qquad n = \frac{(A + \delta_m)/2}{A/2}$$

or $\qquad \boxed{\delta_m = (n - 1)\, A}$

It is clear from this expression that the deviation produced by a thin prism depends only upon the refractive index n of the material of the prism and the angle A of the prism. It does not depend upon the angle of incidence.

Q. 3. Is it essential in your experiment to place the prism in the minimum deviation position? If so, why?

Ans. Yes, it is essential because we obtain a bright and distinct spectrum and magnification is unity i.e. the distance of the object and image from the prism is same. The rays of different colours after refraction diverge from the same points for various colours.

Q. 4. Will the angle of minimum deviation change, if the prism is immersed in water?

Ans. Yes, the refractive index of glass in water is less than air hence angle of minimum deviation becomes less.

Q. 5. Does the angle of minimum deviation vary with the colour of light?

Ans. Yes, it is minimum for red and maximum for violet colour.

Q. 6. Does the deviation not depend upon the length of the base of the prism?

Ans. No, it is independent of the length of the base. By increasing the length of base, resolving power is increased.

Q. 7. What is dispersion and angular dispersion?

Ans. White light is a mixture of lights of different colours. When a beam of white light falls on a prism, it splits into the rays of its constituents colours. This phenomenon is called the 'dispersion' of light.

The reason for the dispersion is that in a material medium the light rays of different colours travel with different speeds although in vacuum (or air) rays of all colours travel with the same speed (3×10^8 m/sec). Hence the refractive index n of a material is different for different colour of light. In glass, the speed of violet light is minimum while that of red light is maximum. Therefore, the refractive index of glass is maximum for the violet light and minimum for the red light ($n_V > n_R$). Hence according to the formula $\delta_m = A(n-1)$, the angle of deviation for the violet light will be greater than the angle of deviation for the red light. When white light enters a prism, then rays of different colours emerge in different directions. The ray of violet colour bends maximum towards the base of the prism, while the ray of red colour bends least. Thus, white light splits into its constituent colours. This is 'dispersion'.

The angle between the emergent rays of any two colours is called 'angular dispersion' between those colours. If δ_R and δ_V be the angles of (minimum) deviation for the red and the violet rays respectively, then the angular dispersion between them is

$$\theta = \delta_R - \delta_V = A\,(n_V - n_R)$$

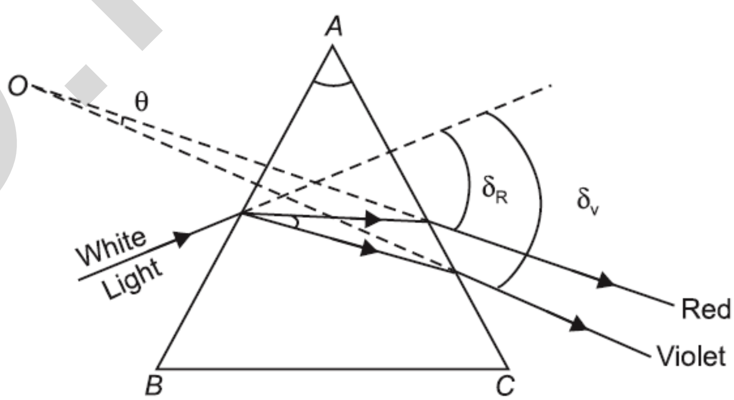


Fig.A7

Note: Higher is deviation, smaller is wavelength i.e. deviation for violet colour is most but wavelength is least.

Q. 8. What is dispersive power?

Ans. When white light passes through a thin prism, the ratio of the angular dispersion between the violet and red emergent rays and the deviation suffered by a mean ray (ray of yellow colour) is called the 'dispersive power' of the material of the prism. It is denoted by ω.

$$\omega = \frac{\delta_V - \delta_R}{\delta_Y} = \frac{n_V - n_R}{n_Y - 1}$$

The dispersive power depends only upon the material of the prism, not upon refracting angle of the prism. Greater is its value for a material, larger is the span of the spectrum formed by the prism made of that material. Dispersive power flint-glass is more than that of crown-glass.

Q. 9. What do you mean by spectrum, impure spectrum and pure spectrum?

Ans. An arrangement of radiation according to their wavelength or frequency is called as spectrum.

When a beam of white light coming from a slit S passes through a prism, it splits up into its constituent colours and form a colour band from red to violet on a screen. This colour band is called 'spectrum'. In this spectrum, the different colours are not distinctly separated, but mutually overlap. Such a spectrum is an 'impure spectrum'. The reason for the *impure spectrum is that the beam of light contains a large number of rays and each ray produces it own spectrum.*

Let the rays 1 and 2 form their spectra R_1V_1 and R_2V_2 respectively which overlap, as shown in FigA9. Clearly, the upper and lower edges of the composite spectrum are red and violet respectively, but in the middle part the colours are mixed.

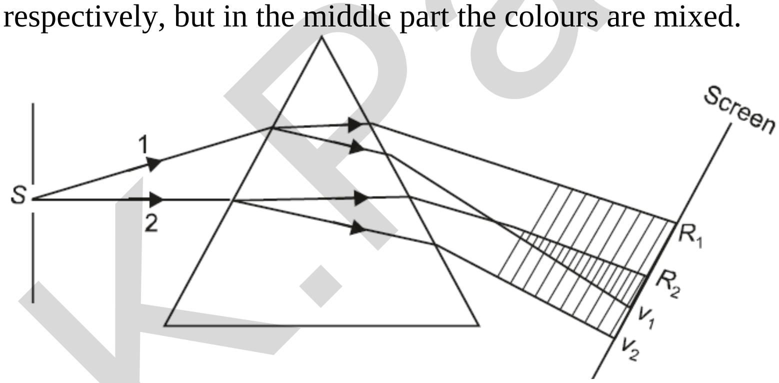


Fig.A9

A spectrum in which there is no overlapping of colours is known as pure spectrum. Each colour occupies a separate and distinct position. In practice, following conditions should be satisfied to obtain a pure spectrum.

(*i*) *The slit should be narrow:* Then only a few rays will fall on the prism and overlapping of colours will be reduced.

(*ii*) The rays falling on the prism should be parallel. Then all the rays will be incident on the prism at the same angle and rays of the same colour emerging from the prism will be parallel to one another which may be focussed at one point.

(*iii*) The rays emerging from the prism should be focussed on the screen by an achromatic convex lens. Then the rays of different colours will be focussed on the screen at different points.

(*iv*) The prism should be placed in minimum-deviation position with respect to the mean ray and the refracting edge of the prism should be parallel to the slit. Then the focusing of different colours at different points will be sharpest.

An arrangement for obtaining a pure spectrum is shown in Fig. B9

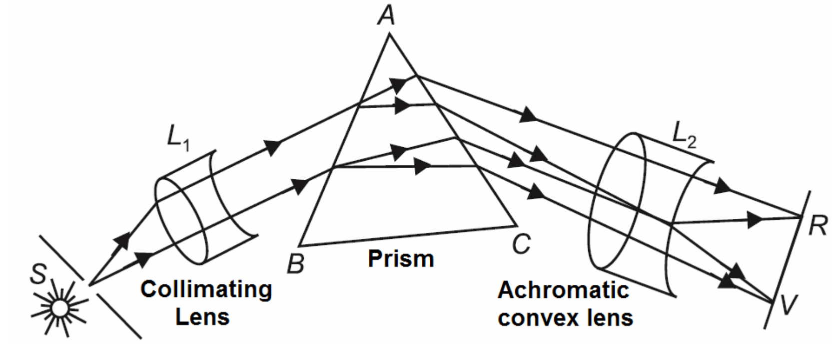
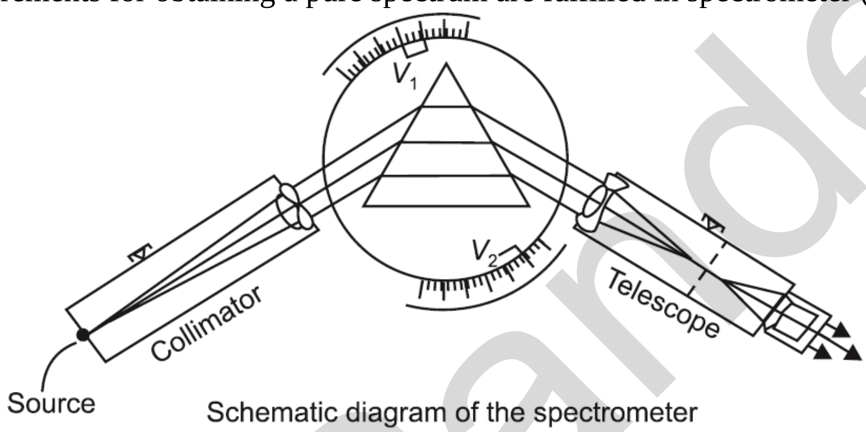


Fig.B9

All requirements for obtaining a pure spectrum are fulfilled in spectrometer (Fig.C9).



Schematic diagram of the spectrometer

Fig.C9

Q.10 . Can you determine the refractive index of a liquid by this method?
Ans. Yes, the experimental liquid is filled in a hollow glass prism.
Q. 11. Which source of light are you using? Is it a monochromatic source of light?
Ans. Neon lamp or mercury lamp. It is not a monochromatic source of light. The monochromatic source contains only one wavelength.
Q. 12. Can you not use a monochromatic source (sodium lamp)?
Ans. Yes, we can use a sodium lamp but it will give only yellow lines and not the full specturm.
Q. 13. What is an eyepiece?
Ans. Eyepiece is a magnifier designed to give more perfect image than obtained by a single lens.
Q. 14. Which eyepiece is used in the telescope of a spectrometer?
Ans. Ramsden's eyepiece.
Q. 15. What is the construction of Ramsden's eyepiece?
Ans. It consists of two plano-convex lenses each of focal length *f* separated by a distance equal to $2f/3$.
Q. 16. What is the construction of Huygen's eyepiece?
Ans. It consists of two plano-convex lenses one having focal length $3f$ and other with focal length *f* and separated at distance $2f$.

Q. 17. What are chromatic and spherical abberration?
Ans. The image of white object formed by a lens is coloured and blurred. This defect is known as chromatic abberration. The failure or inability of the lens to form a point image of a axial point object is called spherical abberration.
Q. 18. How these two defects can be minimised?
Ans. The chromatic aberration can be minimised by taking the separation between two lenses $[d=(f_1+f_2)/2]$. The spherical aberration can be minimised by taking the separation as the difference of two focal lengths $d = (f_1 - f_2)/2$.
Q. 19. What is the main reason for which Ramsden's eyepiece is used with a spectrometer?
Ans. In this eyepiece, the cross wire is outside the eyepiece and hence mechanical adjustment and measurements are possible.
Q. 20. What is a telescope? What is its construction?
Ans. It is an instrument designed to produce a magnified and distinct image of very distinct object. It consists of a convex lens and eyepiece placed coaxially in a brass tube. The lens towards the object is called objective. This is of wide aperture and long focal length. Observations are made by eyepiece. This is fitted in a separate tube which can slide in main tube.
Q. 21. What do you mean by dispersive power? Define it.
Ans. The dispersive power of a material is its ability to disperse the various components of the incident light. For any two colours, it is defined as the ratio of angular dispersion to the mean deviation, i.e.

$$\omega = \frac{\delta_V - \delta_R}{\delta_Y} = \frac{n_V - n_R}{n_Y - 1}$$

Q. 22. On what factors, the dispersive power depends?
Ans. It depends upon (*i*) material and (*ii*) wavelengths of colours.
Q. 23. Out of the prism of flint and crown glasses, which one will you prefer to use?
Ans. We shall prefer a prism of flint glass because it gives greater dispersion.
Q. 24. What is a normal spectrum?
Ans. A spectrum in which angular separation between two wavelengths is directly proportional to difference of the wavelengths is called a normal spectrum.
Q. 25. Do you think that a prismatic spectrum a normal one?
Ans. No.
Q. 26. Can you find out the dispersive power of a prism with sodium light?
Ans. No, this is a monochromatic source of light.
Q. 27. How many types of spectra you know?
Ans. There are two main types of spectra: (*i*) emission spectra and (*ii*) absorption spectra.
Q. 28. What type of spectra do you expect to get from (*i*) an incandescent filament lamp (*ii*) sun light (*iii*) mecury lamp?
Ans. (*i*) continuous spectrum, (*ii*) band spectrum and (*iii*) Line spectrum.
Q. 29. What is difference between a telescope and microscope?
Ans. Telescope is used to see the magnified image of a distinct object. Its objective has large aperture and large focal-length. The microscope is used to see the magnified image of very near object. Its objective has small focal-length and aperture.

Q. 30. Without touching can you differentiate between microscope and telescope?
Ans. The objective of microscope has small aperture while the telescope has a large aperture.
Q. 31. What is that which you are adjusting in focussing the collimator and telescope for parallel rays?
Ans. In case of collimator, we adjust the distance between collimating lens and slit while in case of telescope the distance between cross wires from the objective lens is adjusted.
Q. 32. What are these distances equal to when both the adjustments are complete.
Ans. The slit becomes at the focus of collimating lens in collimator and cross wires become at the focus of objective lens in telescope.
Q. 33. How can telescope and collimator be adjusted together?
Ans. (*i*) the prism is set in minimum deviation for yellow colour.
(*ii*) Prism is rotated towards telescope and telescope is adjusted to get a well defined spectrum.
(*iii*) Now the prism is rotated towards collimator and the collimator is adjusted to get well defined spectrum.
(*iv*) The process is repeated till the spectrum is well focussed. This is known as Schuster's method.
Q. 34. Why do you, often, use sodium lamp in the laboratory?
Ans. Sodium lamp is a convenient source of monochromatic light.
Q. 35. Do you know any other monochromatic source of light?
Ans. Red line of cadmium is also monochromatic source.
Q. 36. Why are two verniers provided with it?
Ans. Because one vernier will not give the correct value of the angle of rotation due to eccentricity of the divided circles with respect to the axis of the instruments. Two verniers eliminates this error.
Q. 37. Why are the lines drawn on the prism table?
Ans. With the help of these lines we can place the prism on the table in any particular manner. For example, when we measure the angle of the prism, we keep the prism such that it is at the centre of the table and one of its faces perpendicular to the line joining two of the levelling screws.
Q. 38. Why are the concentric circles drawn on the prism table?
Ans. These help us in placing the prism on the table such that axis of rotation of the table passes through the centre of the circumscribing circle of the prism.
Q. 39. Why is it necessary to place the prism on the table with the help of lines or circles?
Ans. Because, this minimises the error due to lack of parallism of the incident light.
Q. 40. What conclusion will you draw if the spectrum becomes rapidly worse in this process?
Ans. This means that the adjustments of the collimator and the telescope are being done in the wrong order.

Viva Voce for λ by Newton's Ring

Q. 1. What do you mean by interference of light?
Ans. The redistribution of light by superposition of light waves is called as interference. When the two or more waves superimpose over each other, resultant intensity is modified. The modification in the distribution of intensity in the region of superposition is called interference.
Q. 2. What are interference fringes?
Ans. They are alternately bright and dark patches of light obtained in the region of superposition of two wave trains of light.
Q. 3. Is there any loss of energy in interference phenomenon?
Ans. No, there is no loss of energy in interference phenomenon. Only redistribution of energy takes place. The energy absent at dark places is actually present in bright regions.
Q. 4. What is the physical significance of this phenomenon?
Ans. The phenomenon of interference of light has proved the validity of the wave theory of light.
Q. 5. What are the essential conditions for observing the interference phenomenon in the laboratory?
Ans. (*i*) The two sources should be coherent.
(*ii*) The two sources must emit waves of same wavelength and time period.
(*iii*) The sources should be monochromatic.
(*iv*) The amplitudes of the interfering waves should be equal or nearly equal.
Q. 6. What are the different classes of interference?
Ans. (*i*) Division of wavefront, the incident wavefront is divided into two parts by utilizing the phenomenon of reflection, refraction or diffraction.
(*ii*) Division of amplitude, the amplitude of incoming beam is divided into two parts either by partial reflection or refraction.
Q. 7. What is the construction of sodium lamp?
Ans. It consists of a U-shaped glass tube with two electrodes of tungsten coated with barium oxide. The tube is filled with neon gas at a pressure of 10 mm of mercury and some sodium pieces. This tube is enclosed in a vacuum jacket to avoid heat losses.
Q. 8. Why does the sodium lamp give out red light in the beginning?
Ans. First of all discharge passes through neon gas.
Q. 9. Why is the neon gas filled in it at all?
Ans. Initially, no discharge passes through sodium as its vapour pressure is low. First, the discharge passes through neon. Now the temperature rises and sodium vaporises. Now sodium gives its own characteristic yellow colour.
Q. 10. How are these rings formed?
Ans. When a plano-convex surface is placed on a glass plate, an air film of gradually increasing thickness is formed between the two and monochromatic light is allowed to fall normally on film and viewed in reflected light, alternate dark and bright rings are observed. These are known as Newton's ring.
Q. 11. Why are the rings circular?
Ans. These rings are loci of constant thickness of the air film and these loci being concentric circle hence fringes are circular. OR Since locus of constant thickness of air film about point of contact is circle so fringes are circular.

Q. 12. Why do you use in extended source of light here?
Ans. To view the whole air film, an extended source is necessary.
Q. 13. What may be the reason if the rings are not perfectly circular?
Ans. (*i*) The plate may not be optically flat.
(*ii*) The surface of the lens may not be the part of a perfect sphere and
(*iii*) The plate and the lens may not be perfectly clean.
Q. 14. In the Newton's rings system, the fringes at the centre are quite broad, but they get closer as we move outward why is it so?
Ans. This is due to the fact that the radii of dark rings are proportional to square root of natural numbers while those of bright rings are proportional to square root of odd natural numbers.
Q. 15. What are the factors which govern the radius of a ring?
Ans. The radius depends upon
(*i*) wavelength of light used.
(*ii*) refractive index 'μ' of enclosed film.
(*iii*) radius of curvature R of convex lens.
Q. 16. What would be your observation in transmitted light?
Ans. Where we have bright fringe in the reflected light, we shall have a dark fringe in the transmitted light and vice-versa. These two systems of fringes are complementary.
Q. 17. Do you get rings in the transmitted light?
Ans. Yes, in this case the colour of rings is complimentary of the reflected light.
Q. 18. Why is the centre of the ring dark?
Ans. Although at centre, the thickness of air film is zero but at the point of contact the two interfering rays are opposite in phase and produce zero intensity.
Q. 19. Sometimes the centre is bright, why?
Ans. This happens when a dust particle comes between the two surfaces at the point of contact.
Q. 20. What will happen if the glass plate is silvered on its front surface?
Ans. The transmitted system of fringes will also be reflected and due to the superposition of the reflected and transmitted (which is also reflected now) systems the uniform illumination will result.
Q. 21. If by chance, you get a bright central spot in your experiment, will you proceed with the experiment with the same system of fringes or will you reject them?
Ans. The system will not be rejected, but we will proceed on with measurement, because the formula employed for the evaluation of l involves the difference of the squares of the diameters of two rings and the order of fringe at the centre is immaterial.
Q. 22. What will happen when the sodium lamp is replaced by a white light source?
Ans. A few coloured fringes are observed near the centre. The violet colour will come first as we proceed away from the centre.
Q. 23. What will happen if a few drops of a transparent liquid are introduced between the lens and the plate?
Ans. The fringes will contract, with diameter reduced by a factor of $\sqrt{\mu}$.
Q. 24. Can you utilise this procedure for determining the refractive index of a liquid?
Ans. Yes.

Q. 25. Will there be any change in rings if light is obliquely incident?
Ans. The diameter of the rings will increase.
Q. 26. Why do you make the light fall on the convex lens normally?
Ans. The light is allowed to fall normally so that angles of incidence and reflection may be zero so that cos q may be taken as unity.
Q. 27. In this experiment the rings are observed through the lens. Does it affect the observation of diameter?
Ans. Due to refraction through lens, the observed diameters will be different from their actual values. To avoid this thin lens should be used.
Q. 28. How can you determine R?
Ans. This can be determined either by spherometer or by Boy's method.
Q. 29. Can Newton's rings be formed with the combination of convex and concave lens?
Ans. The plane glass plate is replaced by concave lens i.e. the convex lens is placed over the concave lens.
Q. 30. What are the uses of Newton's rings?
Ans. (*i*) To determine λ of light (monochromatic).
(*ii*) To determine μ of a liquid.
(*iii*) To measure the radius of spherical surface.
(*iv*) To measure expansion coefficient of crystal.

Theory of Newton's Ring

Circular interference fringes can be produced by enclosing a very thin film of air or any other transparent medium of varying thickness between a plane glass plate and a convex lens of a large radius of curvature. Such fringes were first obtained by Newton and are known as Newton's rings.
When a plane-convex lens of long focal length is placed on a plane glass plate, a thin film of air is enclosed between the lower surface of the lens and the upper surface of the plate. The thickness of the air film is very small at the point of contact and gradually increases from the centre outwards. The fringes produced with monochromatic light are circular. The fringes are concentric circles, uniform in thickness and with the point of contact as the centre. When viewed with white light, the fringes are coloured. With monochromatic light, bright and dark circular fringes are produced in the air film.

S is a source of monochromatic light as shown in Fig. N1. A horizontal beam of light falls on the glass plate *B* at 45º. The glass plate *B* reflects a part of the incident light towards the air film enclosed by the lens *L* and the plane glass plate *G*. The reflected beam from the air film is viewed with a microscope, Interference takes place and dark and bright circular fringes are produced. This is due to the interference between the light reflected from the lower surface of the lens and the upper surface of the glass plate *G*.
Theory:
(*i*) *Newton's rings by reflected light:* Suppose the radius of curvature of the lens is *R* and the air film is of thickness *t* at a distance of *OQ* = *r* from the point of contact *O*. Here, interference is due to reflected light. Therefore, for the bright rings

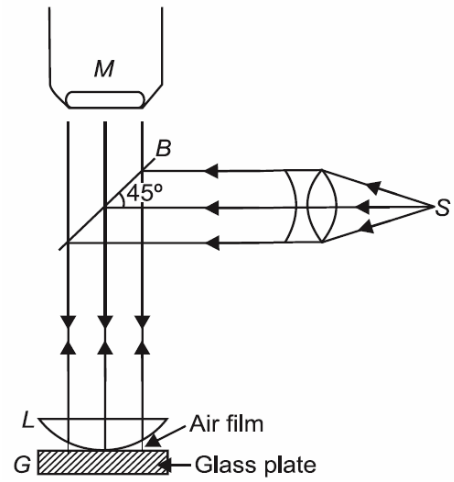


Fig.N1

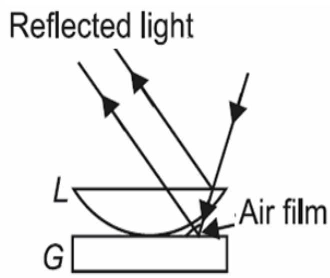


Fig.N2

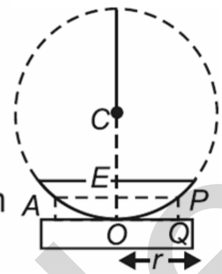


Fig.N3

$$2\mu t \cos\theta = (2n-1)\frac{\lambda}{2} \quad \text{...(i)}$$

where $n = 1, 2, 3, \ldots$ etc.

Here, θ is small, therefore

$$\cos\theta = 1$$

For air, $\mu = 1$

$$2t = (2n-1)\frac{\lambda}{2} \quad \text{...(ii)}$$

For the dark rings

$$2\mu t \cos\theta = n\lambda$$

or

$$2t = n\lambda \quad \text{...(iii)}$$

where $n = 0, 1, 2, 3, \ldots\ldots$ etc.

In Fig N3, $EP \times HE = OE \times (2R - OE)$

But $EP = HE = r,\ OE = PQ = t$

and $2R - t = 2R$ (Approximately)

$$r^2 = 2R \cdot t$$

or

$$t = \frac{r^2}{2R}$$

Substituting the value of t in equations (ii) and (iii).

For bright rings $r^2 = \frac{(2n-1)\lambda R}{2}$

$$\boxed{r = \sqrt{\frac{(2n-1)\lambda R}{2}}}$$

For dark rings

$$r^2 = n\lambda R$$

$$\boxed{r = \sqrt{n\lambda R}}$$

when $n = 0$, the radius of the dark ring is zero and the radius of the bright ring is $\sqrt{\frac{\lambda R}{2}}$. Therefore, the centre is dark. Alternately, dark and bright rings are produced.

Result: The radius of the dark ring is proportional to

(*i*) $\sqrt{n}$, (*ii*) $\sqrt{\lambda}$ and (*iii*) $\sqrt{R}$.

Similarly the radius of the bright ring is proportional to

(*i*) $\sqrt{\frac{(2n-1)}{2}}$, (*ii*) $\sqrt{\lambda}$ and (*iii*) $\sqrt{R}$.

If D is the diameter of the dark ring

$$D = 2r = 2\sqrt{n\lambda R}$$

For the central dark ring

$$n = 0$$

$$D = 2\sqrt{n\lambda R} = 0$$

This corresponds to the centre of the Newton's rings.

While counting the order of the dark rings 1, 2, 3 etc, the central ring is not counted.

Therefore for the first dark ring

$$n = 1$$

$$D_1 = 2\sqrt{\lambda R}$$

For the second dark ring

$$n = 2$$

$$D_2 = 2\sqrt{2\lambda R}$$

and for the n^{th} dark ring

$$D_n = 2\sqrt{n\lambda R}$$

Take the case of 16^{th} and 9^{th} rings

$$D_{16} = 2\sqrt{16\lambda R} = 8\sqrt{\lambda R}$$

$$D_9 = 2\sqrt{9\lambda R} = 6\sqrt{\lambda R}$$

The difference in diameters between the 16th and the 9th rings,

$$D_{16} - D_9 = 8\sqrt{\lambda R} - 6\sqrt{\lambda R} = 2\sqrt{\lambda R}$$

Similarly the difference in the diameters between the fourth and first rings,

$$D_4 - D_1 = 2\sqrt{4\lambda R} - 2\sqrt{\lambda R} = 2\sqrt{\lambda R}$$

Therefore, the fringe width decreases with the order of the fringe and the fringes get closer with increase in their order.

For bright rings,

$$r_n^2 = \frac{(2n-1)\lambda R}{2}$$

$$D_n^2 = \frac{2\,(2n-1)\,\lambda R}{2}$$

$$r_n = \sqrt{\frac{(2n-1)\,\lambda R}{2}}$$

In above equation, substituting $n = 1, 2, 3$ (number of the ring) the radii of the first, second, third etc., bright rings can be obtained directly.

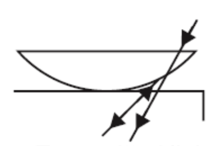
(ii) *Newton's rings by transmitted light:*

In the case of transmitted light, the interference fringes are produced such that for bright rings,

$$2\mu t \cos\theta = n\lambda$$

and for dark rings

$$2\mu t \cos\theta = (2n-1)\frac{\lambda}{2}$$



Here, for air $\mu = 1$, and $\cos\theta = 1$

For bright rings $2t = n\lambda$

and for dark rings $2t = (2n-1)\frac{\lambda}{2}$

Taking the value of $t = \frac{r^2}{2R}$, where r is the radius of the ring and R the radius of curvature of the lower surface of the lens, the radius for the bright and dark rings can be calculated.

For bright rings, $r^2 = n\lambda R$

For dark rings, $r^2 = \frac{(2n-1)\lambda R}{2}$

where $n = 1, 2, 3, ...,$ etc.

When $n = 0$, for bright rings $r = 0$

Therefore, in the case of Newton's rings due to transmitted light, the central ring is bright i.e. just opposite to the ring pattern due to reflected light.

DETERMINATION OF THE WAVELENGTH OF SODIUM LIGHT USING NEWTON'S RINGS

The arrangement used is shown earlier. In Figure S is a source of sodium light. A parallel beam of light from the lens L_1 is reflected by the glass plate B inclined at an angle of 45° to the horizontal. L is a plano-convex lens of large focal length. Newton's rings are viewed through B by the travelling microscope M focussed on the air film. Circular bright and dark rings are seen with the centre dark. With the help of a travelling microscope, measure the diameter of the n^{th} dark ring.

Suppose, the diameter of the n^{th} ring $= D_n$

$$r_n^2 = n\lambda R$$

But $$r_n = \frac{D_n}{2}$$

$$\therefore \quad \frac{(D_n)^2}{4} = n\lambda R$$

or $$D_n^2 = 4n\lambda R \qquad ...(i)$$

Measure the diameter of the $(n + m)$th dark ring.

Let it be D_{n+m} $\therefore$ $\frac{(D_{n+m})^2}{4} = (n+m)\lambda R$

or $$(D_{n+m})^2 = 4(n+m)\lambda R \qquad ...(ii)$$

Subtracting (i) from (ii)

$$(D_{n+m})^2 - (D_n)^2 = 4m\lambda R$$

$$\lambda = \frac{(D_{n+m})^2 - (D_n)^2}{4mR}$$

Hence, λ can be calculated. Suppose the diameters of the 5^{th} ring and the 15^{th} ring are determined. Then $m = 15 - 5 = 10$.

$$\therefore \quad \lambda = \frac{(D_{15})^2 - (D_5)^2}{4 \times 10R}$$

The radius of curvature of the lower surface of the lens is determined with the help of a spherometer but more accurately it is determined by Boy's method.

Hence the wavelength of a given monochromatic source of light can be determined.