

SUBJECT: PHYSICSTOPIC: Wave Optics

Pre-Content/content Post-Content	Learning outcomes/Objectives	
	General	Specific
PRE-CONTENT: Q1What is the nature of light waves? Q2State the laws of reflection. Q3What is meant by Dual nature of light? Q4Which all features of light indicate wave nature of light CONTENT <u>Nature of light</u> wave front and Rays Huygen's principle of secondary wavelets, reflection and refraction of waves on the basis of wave theory, Effect on wavelength, frequency and speed during refraction, refraction of a plane wave by thin prism , convex lens , concave mirror.	Students will be able to: • <u>define</u> Wave front • <u>explain</u> various types of wave fronts Spherical cylindrical, plane • <u>understand & State</u> Huygen's postulates of wave theory, • <u>prove</u> Laws of refraction & reflection by wave theory	Students will be able to: • realize wave nature of light • distinguish the terms: wave front, rays wavelets , • identify different type of wave fronts • state Huygen's principle of secondary wavelets. • apply Huygen's principle to derive (i) laws of reflection (ii) laws of refraction of a plane wave front at a plane surface. • Comprehend effect on wavelength, frequency and speed during refraction • draw diagrams showing refraction of a plane wave by a- thin prism , convex lens , a concave mirror.

Teacher's Activity	Student's Activity	Teacher's observation and Remedial
Teacher will • enable students to recall the concepts related to light learnt by students in previous classes in order to figure out the level of their knowledge accordingly the new concepts will be introduced. • Introduce the concept of wave front of light by giving the analogy of waves produced in a silent pond by dropping a small pebble into it. • divide class into groups and each group would be assigned a topic for preparing presentations- various types of wave fronts, corresponding rays, Huygen's postulates, proof of laws of reflection and refraction based on Huygen's postulates will be discussed in the class in an interactive manner by using various available resources- PPTs prepared by students topic wise, YouTube links, swayam portal etc	Students will • recall the basics learnt in class X & chapter9 in class XII related to wave theory of light • be divided into four groups and each group would be assigned a topic accordingly students will give presentations as per the topic assigned to them under the able guidance of teacher i.e. wave front, Huygen's principle, reflection and refraction of plane waves at a plane surface using Huygen's principle . They will also draw diagrams showing refraction of a plane wave by a) thin prism b) convex lens c) reflection of a plane wave by a concave mirror.	

Pre-Content/content Post-Content	Learning outcomes/Objectives	
Principle of superposition of waves	General	Specific
Interference of light-Young's double slit experiment -coherent and incoherent sources -conditions for maxima and minima in interference and fringe width -Intensity distribution curve -conservation of energy in interference -Interference with white light Diffraction of light -diffraction at a single slit -interference and diffraction patterns - diffraction as limit on resolving power of optical instruments. -Fresnel distance	Students would be able to: • differentiate coherent and incoherent sources of light • explain Interference • calculate conditions for maxima and minima in interference • derive expression for fringe width in interference • analyse the situation of interference when white light is used • explain diffraction, calculate conditions for maxima and minima in diffraction • derive expression for fringe width in diffraction • analyse the situation when white light is used in diffraction • understand the concept of resolving power • learn resolving power of telescope and microscope	Students would be able to: • state and explain principle of superposition • explain the term interference of light. • describe Young's double slit experiment • derive the condition for constructive and destructive interference • comprehend the terms, phase difference, path difference and coherent sources • derive the conditions for maxima and minima in interference • differentiate Coherent and incoherent sources • understand the conditions for observing sustained interference of light • deduce mathematical expression for the fringe width in Young's double slit experiment. • solve problems on interference and related concepts. • explain the result of interference when white light is used • plot intensity distribution curve • justify interference to be in accordance with law of conservation of energy • compare intensities of maxima and minima • explain and illustrate the phenomenon of diffraction of light • explain diffraction of light at a single slit through superposition of secondary wavelets • draw the intensity distribution graph for diffraction at a single slit and explain fall in intensity of secondary maxima • compare interference pattern and diffraction pattern • deduce mathematical expression for the angular/linear width of Central maxima. • know the conditions for maxima and minima. • appreciate the reasons for rapid fall in intensity of the secondary maxima.. • conceptualize validity of Fresnel distance

Teacher's Activity	Student's Activity	Teacher's observation and Remedial
Teacher will • Present using gratings demonstrations on the phenomenon of interference and Diffraction followed by theoretical analysis, derivation of fringe width and differences between the two. The Phenomenon of interference will also be clarified further by conducting a simple activity using rope with patches of equal length painted in red and white colour <u>(Annexure 10 A)</u> <u>(attached at the end)</u> . • explain resolving power of microscope and telescope, difference between magnification and resolution by taking suitable examples • explain the meaning and facilitate students in deriving the expression of 'Fresnel distance' and its significance in defining the range of validity of ray optic	Students will • witness all the demonstrations presented by teacher and they will comprehend the concept of coherent sources, and set up of Young's double slit experiment and diffraction using gratings and other teaching aids. They will obtain the expression for fringe width and compare intensity variation of fringes formed in both the cases analyse the factors by which resolution of microscope and telescope increases/decreases solve the related numerical problems in order to understand the concept of 'Fresnel distance' 4/14	

Pre-Content/content Post-Content	Learning outcomes/Objectives	
RP of microscope and telescope	General	Specific
	Students will be able to: • <u>explain</u> polarisation • <u>define</u> linearly polarised light & unpolarised light • <u>explain</u> polarisation by reflection • <u>derive</u> Brewster's Law • <u>understand</u> law of Malus • <u>illustrate</u> uses of polaroid	Students would be able to: • define the terms limit of resolution and resolving power „ • define resolving power of a microscope and telescope and write mathematical expressions for these • comprehend the advantage of oil immersion objective of a microscope. • compare resolution and magnification • explain the phenomenon of polarization of light taking example of mechanical waves • differentiate polarized light from unpolarised • conclude that only transverse waves can be polarised • distinguish between plane of vibration, and place of polarization • state and explain law of Malus • sketch graph showing the dependence of intensity of transmitted light on angle between polarizer and analyser • explain 'Polarization by scattering'. • explain Polarisation by reflection • state and prove Brewster's law . • explain polaroids and their uses.
Polarization of light - Unpolarised and plane polarized light, Polarisers - law of Malus - Plane of polarization and vibration - polarization by reflection (Brewster's law) - polarization by scattering - Polaroids		

Teacher's Activity	Student's Activity	Teacher's observation and Remedial
Teacher will - Present a simple activity of making laser light incident on a porcelain saucer through a polaroid sheet by rotating the laser about its axis and observing the variation in the intensity of spot formed on the saucer <u>(Annexure 10 B) (attached at the end)</u> *facilitate students to distinguish between plane of vibration, and plane of polarization, state the meaning of plane polarized light, know the basic details of 'Polarization by scattering', Understand the production of Polarized light by reflection, state and derive Brewster's law and Malus law. - prepare assignment consisting of a variety of, direct, conceptual, numerical and previous years board problems and guide students to solve it <u>(Annexure 10 C,10D) (attached at the end)</u>	Students will - Witness the demonstration on polarization presented by the teacher and appreciate the fact that why the phenomenon of polarization can be associated only with transverse waves further understand the concept of Polarization by observing the variation in the intensity of sunlight made to pass through pair of coaxial Polaroids, free to rotate about their common axis They will also list various uses of polaroid - Students will solve the NCERT in text questions and back exercise. They will also solve the assignment consisting of a variety of conceptual, numerical and previous years' board problems under the guidance of teacher.	

TEACHING AIDS: Textbooks, Smartboard, ICR, Equipments from the Physics Lab.

METHODOLOGY/ INNOVATIVE METHODS: Activity based teaching, discussion method, hands on experience

HOMEWORK: Self Reading of the Chapter, NCERT Exercise, Assignment consisting of conceptual and numerical problems **(Annexure 10 C, 10D) (attached at the end)**

HOD

COORDINATOR

VICE PRINCIPAL

PRINCIPAL

Annexure 10 A ACTIVITY - (Interference- The phenomenon of redistribution of light)

Subject	Physics
Class	XII
Chapter/Unit	Wave Optics
Topic	Interference of light-<u>(Interference- The phenomenon of redistribution of light)</u>
Time	15min
Nature of Activity	Pair activity

What will I learn (Learning Outcome)?

Conditions for obtaining constructive and destructive interference

Skills:

Observing, Analyzing, Interpreting

What I have to do?

To derive the conditions for constructive and destructive interference

What do I require?

A long rope of length 4m, Red and Black paint colors, painting brush, meter scale(serving the purpose of screen)

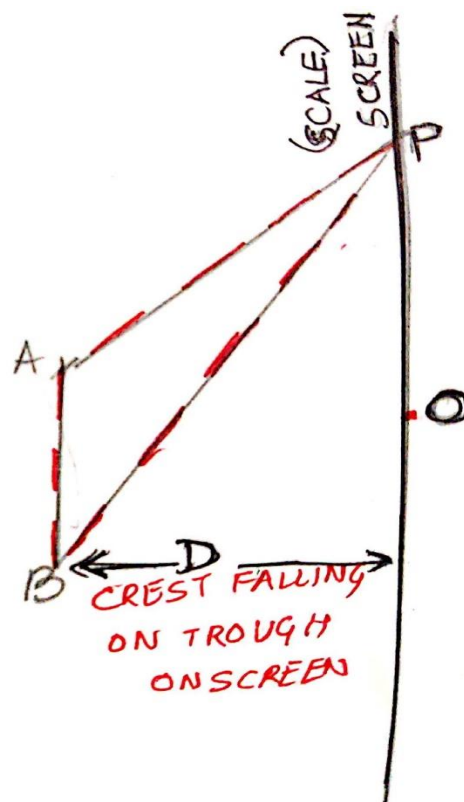
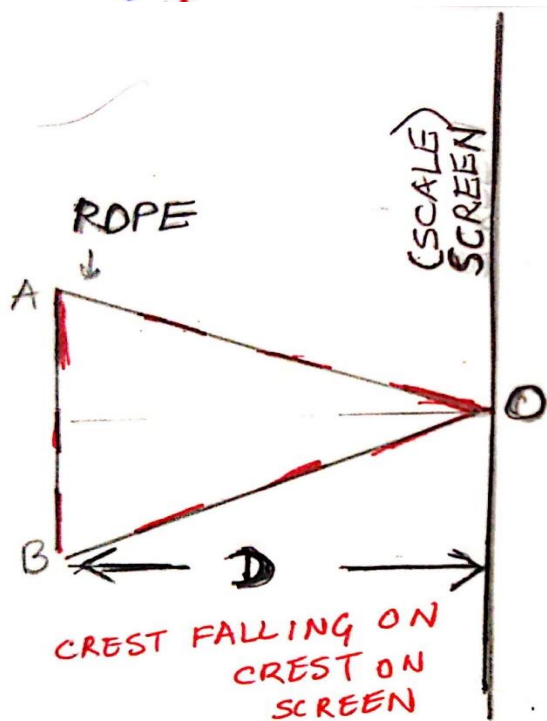
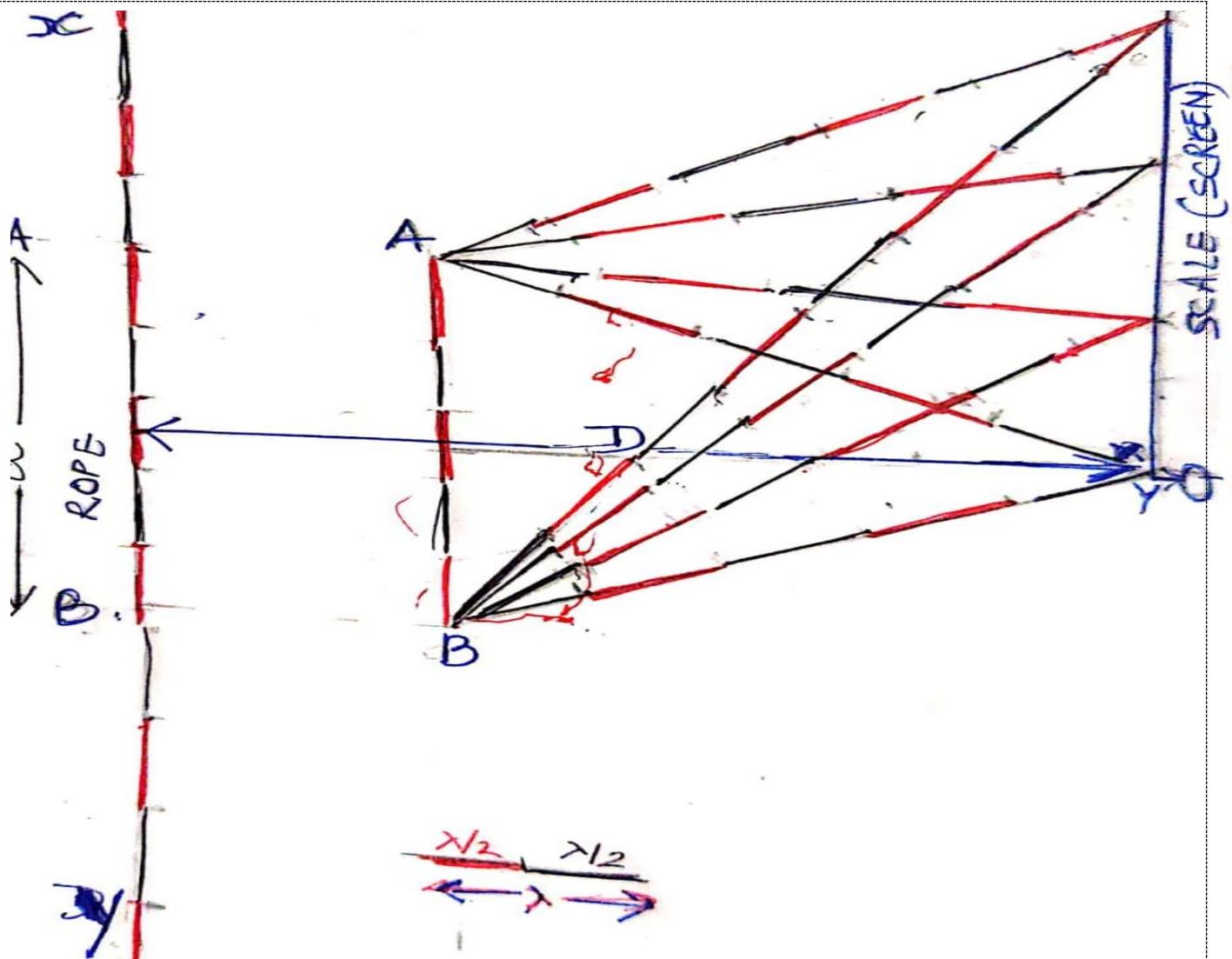
What do I need to know?

Superposition of waves, Interference of light, Young's double slit experiment

➤ Teacher's Activity

Teacher will

- Enable students to recall Young's double slit experiment
- facilitate students to perform a simple activity to make them understand the conditions for obtaining constructive and destructive interference



How will I proceed?

➤ Student's Activity

- Students will paint rope alternately red and black each portion of length 10cm
- Hold a scale vertically on a stand
- One student will hold vertically a segment(AB) of length 40cm from the central portion of the rope parallel to the scale at some distance from it such that zero of the scale lies on perpendicular bisector of AB. Another student will hold the free ends X and Y of the rope together such that the rope pieces BY and AX are equal, taut and coincide with zero mark on the scale
- Second student will move hands up along the scale such that the rope pieces in his hand remain taut throughout while the hand moves up along the scale, by adjusting the portion of rope pieces held in hand.
- While moving the hands up along the scale, by adjusting the length of rope pieces held in hand, such that all the time they remain taut throughout, note the position on scale when the colored patches on the two ropes falling on the scale become identical i.e. red on red or black on black and also the positions where opposite colored patches fall over the scale i.e. red on black and vices versa

What have I observed?

Red stands for crest, Black stands for trough

S. No.	Color of the patches falling on the scale, while the second child moves the hand up along the scale	Difference in length of the two portions rope when the hand holding them taut is at point P on the scale(AP-BP)	Division on the scale
1	Red on Red		
2	Red on black		
3	Black on Black		
4	Red on Black		
5	Red on Red		

If red represents crest and black represents trough of a wave, then red and black together represent-----(λ or $\lambda/2$). On the scale, falling of red on red or white on white represents----- (constructive/destructive) interference at that moment the difference in lengths of the rope pieces held in hand is ----- $\{n\lambda$ or $(2n+1)\lambda/2\}$. Falling of red on black or vices-versa represents ----- (constructive/destructive) interference at that moment the difference in lengths of the rope pieces held in hand is ----- $\{n\lambda$ or $(2n+1)\lambda/2\}$.

What have I learnt?

At any point P on the scale(serving the purpose of screen) Constructive Interference occurs when path difference between AP and BP is integral multiple of-----(λ or $\lambda/2$) and destructive

interference occurs when path difference between AP and BP is odd integral multiple of -----
---(λ or $\lambda/2$)

What am I curious to learn?

How will the intensity of maxima and minima, in the Young's double slit experiment change, if one of the two slits is covered by a transparent paper which transmits only half of the light intensity

(**Clue :** Intensity of maxima decreases and that of minima increases)

Let me evaluate myself

Q1) Draw a picture of two traveling waves that add up to form constructive interference.

Q2): Draw a picture of two traveling waves that add up to form destructive interference.

Q3) Let y be the distance between any point P located on the screen and the point O on the screen which is located on the perpendicular bisector of the line joining the slits. Find a relation between the distance y , the wavelength λ , the distance between the slits d , and the distance of the screen D from the slits such that a constructive interference pattern will occur at the point P.

Q4) When two waves of same frequency and amplitude add constructively, the intensity becomes

- a) Double
- b) Half
- c) Four Times
- d) One-Fourth

Q5) If instead of monochromatic light white light is used for interference of light, what would be the change in the observation?

- a) The pattern will not be visible
- b) The shape of the pattern will change from hyperbolic to circular
- c) Colored fringes will be observed with a white bright fringe at the center
- d) Colored fringes will be observed with a blue fringe at the center

Q6) In YDSE Zero order fringe can be identified using _____

- a) White light
- b) Yellow light
- c) Achromatic light
- d) Monochromatic light

Q7) Interference is observed for light produced by two coherent sources only when the phase difference between the two waves is zero.

- a) True
- b) False

Q8) The shape of the interference pattern obtained in YDSE depends on the _____

- a) distance between the slits
- b) distance between the slits and the screen
- c) wavelength of light
- d) shape of the slit

Q9) What happens to the interference pattern if the phase difference between the two sources varies continuously?

Q10) If the path difference produced due to interference of light coming out two slits for green color of light at a point is $3\lambda/2$. What will be the color of the fringe at the point,if

- (i) green light is used
- (ii) white light is used

Q11) In Young's double slit experiment, lights of blue,yellow and orange colours are successively used.Write the fringe width for three colours in increasing order.

Q12) How will the expression of fringe width change, when the entire apparatus of Young's double slit experiment is immersed in a liquid of refractive index μ .

Q13) Why is it comparatively difficult to observe interference in light waves as compared to that in water waves.

(Annexure 10 B) ACTIVITY - Polarisation of light-

Subject	PHYSICS
Class	XII
Chapter/Unit	Wave Optics
Topic	Polarisation of light-
Time	10min
Nature of Activity	Individual

What will I learn (Learning Outcome)?

Polarisation of light

Skills:

observing, analyzing, reasoning, logical ability

What I have to do?

To demonstrate polarisation of light experimentally

What do I require?

Laser, Polaroid sheet,, Porcelain plate/saucer

What do I need to know?

Basic aspects of polarisation-Light is transverse in nature and like transverse mechanical waves it can also be polarised..

➤ **Teacher's Activity**

Teacher will

- make students recall the definition of polarisation of light , the difference between polarised and unpolarised light, action of polaroid.
- facilitate students to perform a simple activity to make them understand the phenomenon of polarisation of light experimentally **11/14**

How will I proceed?

➤ Student's Activity

Student will

- Make laser light shine over a saucer and observe intensity of the bright spot on the saucer
- Rotate the pencil laser about its axis and note the intensity of bright spot on the saucer
- Place a polaroid sheet in the path of laser light falling on the saucer and rotate the laser light about its axis and note the change in the intensity of bright spot on the saucer

What have I observed?

S. No.	Condition	Intensity of brightness of spot on the saucer
1	Laser light made incident on the saucer directly	
2	Laser light made incident on the saucer while the laser rotates about its vertical axis	
3	Laser light made incident on the saucer via polaroid	
4	Laser light made incident on the saucer via polaroid while the laser rotates about its axis	

What have I learnt? As the intensity of light spot on saucer -----(remains same/ changes) when the Laser light is made incident on the saucer through a polaroid on being rotated about its vertical axis. This implies that the light of the given laser is -----(Polarised/ unpolarised). This phenomenon is known as-----, and it can be defined as-----

What am I curious to learn?

How does the intensity of the transmitted light varies when a beam consisting of an unpolarised and a plane polarised part is viewed through a polariser while the polariser rotates through one full circle, about the direction of propagation of the beam as axis,

Let me evaluate myself

Q1 A linearly polarised wave is always _____

- a) in x-y plane
- b) a Transverse wave
- c) a Longitudinal wave
- d) in x-z plane

Q2) The intensity of light transmitted by a polaroid is-----of the intensity of the unpolarised light incident on it

- a) half
- b) one fourth
- c) one eighth
- d) one sixteenth

Q3) Can ultrasonic waves be polarised? Give reason for your answer.

Q4) If the polarising angle for air-glass interface is 56.3° , What is the angle of refraction in glass?

Q5) At what angle of incidence should a light beam strike a glass slab of refractive index $\sqrt{3}$, such that the reflected and refracted rays are perpendicular to each other?

Q6) The velocity of light in some medium is 1.5×10^8 m/s. What is the polarizing angle of incidence?

- a) 47.23°
- b) 52.02°
- c) 53.74°
- d) 63.43°

Q7) An electromagnetic beam has an intensity 16 W/m^2 and is linearly polarised vertically. What is the intensity of the transmitted beam, if the angle of incidence on the polaroid is 45° with the vertical?

- a) 8 Wm^{-1}
- b) 12 Wm^{-1}
- c) 16 Wm^{-1}
- d) 24 Wm

Q8) Unpolarised light is incident on a plane glass surface. What should be the angle of incidence such that the reflected and refracted rays are perpendicular to each other?

- a) 90°
- b) 30°
- c) 57°
- d) 60°

Q9) A beam of unpolarised light, of intensity I_0 , is passed through a polaroid A. It is then passed through another polaroid, B, which is oriented so that its principal plane makes an angle of 45° , relative to that of A. The intensity of emergent light, is

- a) $2 I_0$
- b) $I_0/2$
- c) $I_0/4$
- d) $I_0/8$

Q10) With the help of diagram explain the terms- plane of polarization and plane of vibration
.(Annexure 10 C) Wave Optics(Direct Questions)

Q1(i) Define the term wavefront and Rays.

(ii) Draw plane, cylindrical, spherical wavefront.

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(iii) Draw wavefronts corresponding to converging, diverging and parallel rays of light.

Q2 State and explain Huygen's postulates of wave theory

Q3 Derive laws of refraction by using Huygen's wave theory of light.

Q4 Derive laws of reflection by using Huygen's wave theory of light.

Q5. Explain the action of a prism, a convex lens and a concave mirror, with the help of neat and labelled diagram, when a plane wavefront is incident on each of them.

Q6 Derive the expression for the intensity of a resultant wave when two waves interfere in Young's double slit experiment. Hence derive the conditions for constructive and destructive interference

Q7.(i) What are coherent sources? What are the conditions for two sources to be coherent? Can two independent light sources be coherent

(ii) What is the relationship between Path difference & Phase difference

Q8.(i) Deduce the expression for fringe width in Young's double Slit Experiment.

Q9. Draw and explain the graph showing the variation of intensity in the Young's double Slit Experiment

Q10. Show that the phenomenon of interference is in accordance with law of conservation of energy.

Q11. Derive an expression for the ratio of intensities at maxima and minima in an interference pattern.

Q12. Explain the effect on interference fringes in a Young's double Slit Experiment when

(i) the monochromatic source is replaced by a source of white light.

(ii) the whole apparatus is dipped in water

Q13. What is diffraction of light? Why is diffraction more pronounced in case of sound waves?

Q14.(i). Explain the formation of diffraction fringes using single slit. Why is the intensity of secondary maxima less than that of central maxima.

(ii) Derive the expression for angular and linear width of central maxima and secondary maxima.

(iii) Draw and explain the graph showing the variation of intensity distribution in Single Slit diffraction

Q15 Prove that Ray optics is the limiting case of wave optics and derive the expression for Fresnel's distance

Q16 Give some important points of difference between Interference and Diffraction.

Q17.(i) Distinguish between Polarized and unpolarised light

(ii) Can longitudinal waves be polarised

Q18 State and explain law of Malus. Sketch a graph showing the variation of intensity of transmitted light with angle between analyser and polariser

Q19. Explain polarisation by scattering

Q20. Explain polarisation by Reflection and hence state and explain Brewster's Law

Q21. Mention few uses of polaroids **Q22.** Define the following terms

(i) Resolving power

(ii) limit of resolution

Q23 write the expression for resolution of

(i) microscope (ii) telescope

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