PHYSICS

NCERT - NCERT PHYSICS(GUJRATI)

WAVE OPTICS

Example

1. What speed should a galaxy move with respect to us so that the sodium line at 589.0 nm is observed at 589.6 nm?

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2. (a) When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency. Explain why?

(b) When light travels from a rarer to a denser medium, the speed decreases. Does the reduction in speed imply a reduction in the energy carried by the light wave?

(c) In the wave picture of light, intensity of

light is determined by the square of the amplitude of the wave. What determines the intensity of light in the photon picture of light

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3. Two slits are made one millimetre apart and the screen is placed one metre away. What is the fringe separation when bluegreen light of wavelength 500 nm is used?

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4. What is the effect on the interference fringes in a Young's double-slit experiment due to each of the following operations:

(a) the screen is moved away from the plane of the slits,

(b) the (monochromatic) source is replaced by another (monochromatic) source of shorter wavelength,

(c) the separation between the two slits is increased,

(d) the source slit is moved closer to the double-slit plane,

(e) the width of the source slit is increased,

(f) the monochromatic source is replaced by a source of white light?

(In each operation, take all parameters, other than the one specified to remain unchanged.)

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5. In Example 10.3, what should the width of each slit be to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern?

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6. Assume that light of wavelength 6000Å is coming from a star. What is the limit of resolution of a telescope whose objective has a diameter of 100 inch?

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7. For what distance is ray optics a good approximation when the aperture is 3 mm wide and the wavelength is 500 nm?

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8. Discuss the intensity of transmitted light when a polaroid sheet is rotated between two crossed polaroids?

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9. Unpolarised light is incident on a plane glass surface. What would be the angle of

incidence so that the reflected and refracted rays are perpendicular to each other.

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Exercises

1. Monochromatic light of wavelength 589 nm is incident from air on a water surface. What are the wavelength, frequency and speed of (a) reflected, and (b) refracted light? Refractive index of water is 1.33.

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2. What is the shape of the wavefront in each of the following cases:

(a) Light diverging from a point source.

(b) Light emerging out of a convex lens when a point source is placed at its focus.

(c) The portion of the wavefront of light from a distant star intercepted by the Earth.

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3. (a) The refractive index of glass is 1.5. What is the speed of light in glass? $\left(\text{Speed of light in vacuum is } \ 3.0 \times 10^{8} ms^{-1}\right)$ (b) Is the speed of light in glass independent of the colour of light? If not, which of the two colours red and violet travels slower in a glass prism?

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4. In a Young's double-slit experiment, the slits are separated by 0.28 mm and the screen is placed 1.4 m away. The distance between the central bright fringe and the fourth bright fringe is measured to be 1.2 cm. Determine the wavelength of light used in the experiment.

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5. In Young's double-slit experiment using monochromatic light of wavelength λ, the

intensity of light at a point on the screen where path difference is λ, is K units. What is the intensity of light at a point where path difference is $\lambda/3$?

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6. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment.

(a) Find the distance of the third bright fringe

on the screen from the central maximum for wavelength 650 nm.

(b) What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?

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7. In a double-slit experiment the angular width of a fringe is found to be 0.2° on a screen placed 1 m away. The wavelength of light used is 600 nm. What will be the angular

width of the fringe if the entire experimental apparatus is immersed in water? Take refractive index of water to be 4/3.

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8. What is the Brewster angle for air to glass transition? (Refractive index of glass = 1.5.)

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9. Light of wavelength 5000Å falls on a plane reflecting surface. What are the wavelength and frequency of the reflected light? For what angle of incidence is the reflected ray normal to the incident ray?

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10. Estimate the distance for which ray optics is good approximation for an aperture of 4 mm and wavelength 400 nm.

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11. The $6563 \text{Å} H\alpha$ line emitted by hydrogen in a star is found to be redshifted by 15Å. Estimate the speed with which the star is receding from the Earth.

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12. Explain how Corpuscular theory predicts the speed of light in a medium, say, water, to be greater than the speed of light in vacuum.

Is the prediction confirmed by experimental determination of the speed of light in water? If not, which alternative picture of light is consistent with experiment?

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13. You have learnt in the text how Huygens' principle leads to the laws of reflection and refraction. Use the same principle to deduce directly that a point object placed in front of a plane mirror produces a virtual image whose

distance from the mirror is equal to the object distance from the mirror

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14. Let us list some of the factors, which could possibly influence the speed of wave propagation:

(i) nature of the source.

(ii) direction of propagation.

(iii) motion of the source and/or observer.

(iv) wavelength.

(v) intensity of the wave.

On which of these factors, if any, does

(a) the speed of light in vacuum,

(b) the speed of light in a medium (say, glass or water), depend?

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15. For sound waves, the Doppler formula for frequency shift differs slightly between the two situations: (i) source at rest, observer moving, and (ii) source moving, observer at

rest. The exact Doppler formulas for the case of light waves in vacuum are, however, strictly identical for these situations. Explain why this should be so. Would you expect the formulas to be strictly identical for the two situations in case of light travelling in a medium?

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16. In double-slit experiment using light of wavelength 600 nm, the angular width of a

fringe formed on a distant screen is 0.1^{o}. What is the spacing between the two slits?

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17. Answer the following questions:

(a) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band?

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18. Answer the following questions:

(b) In what way is diffraction from each slit related to the interference pattern in a double-slit experiment?

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19. Answer the following questions:

(c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain why?

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20. Answer the following questions:

(d) Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend aroundobstacles, how is it that the students are unable to see each other even though they can converse easily.

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21. Answer the following questions:

(e) Ray optics is based on the assumption that light travels in a straight line. Diffraction effects (observed when light propagates through small apertures/slits or around small obstacles) disprove this assumption. Yet the ray optics assumption is so commonly used in understanding location and several other properties of images in optical instruments. What is the justification?

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22. Two towers on top of two hills are 40 km apart. The line joining them passes 50 m above a hill halfway between the towers. What is the longest wavelength of radio waves, which can be sent between the towers without appreciable diffraction effects?

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23. A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m

away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen. Find the width of the slit.

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24. Answer the following questions:

(a) When a low flying aircraft passes overhead, we sometimes notice a slight shaking of the picture on our Tv screen. Suggest a possible explanation.

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25. Answer the following questions:

(b) As you have learnt in the text, the principle of linear superposition of wave displacement is basic to understanding intensity distributions in diffraction and interference patterns. What is the justification of this principle?

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26. In deriving the single slit diffraction pattern, it was stated that the intensity is zero at angles of $n\lambda/a$. Justify this by suitably dividing the slit to bring out the cancellation.

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