DPP - Daily Practice Problems

Name : Date :

Start Time : End Time :

PHYSICS 53

SYLLABUS : WAVE OPTICS - II (Diffraction and polarisation of light)

Max. Marks : 120 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.22) : There are 22 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 The first diffraction minima due to a single slit diffraction is at $\theta = 30°$ for a light of wavelength 5000Å. The width of the slit is-

(a) 5×10^{-5} cm (b) 1.0×10^{-4} cm
(c) 2.5×10^{-5} cm (d) 1.25×10^{-5} cm

Q.2 Two spectral line of sodium D_1 & D_2 have wavelengths of approximately 5890Å and 5896Å. A sodium lamp sends incident plane wave on to a slit of width 2 micrometre. A screen is located at 2m from the slit. Find the spacing between the first maxima of two sodium lines as measured on the screen.

(a) 10^{-4} m (b) 9×10^{-4} m
(c) 9×10^{4} m (d) None

Q.3 Width of slit is 0.3mm. Fraunhoffer diffraction is observed in focus plane of lense of a lense of focal length 1 m. If third minima is at 5 mm distance from central maxima, then wavelength of light is-

(a) 7000Å (b) 6500Å (c) 6000Å (d) 5000Å

Q.4 When a wave of wavelength 0.2 cm is made incident normally on a slit of width 0.004m, then the semi-angular width of central maximum of diffraction pattern will be-

(a) 60° (b) 30° (c) 90° (d) 0°

Q.5 A parallel beam of monochromatic light is incident on a narrow rectangular slit of width 1mm. When the diffraction pattern is seen on a screen placed at a distance of 2m. the width of principal maxima is found to be 2.5 mm. The wave length of light is-

(a) 6250 nm (b) 6200 nm
(c) 5890 nm (d) 6000 nm

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

Space for Rough Work

Q.6 Light of wavelength 6328Å is incident normally on slit having a width of 0.2 mm. The width of the central maximum measured from minimum to minimum of diffraction pattern on a screen 9.0 meters away will be about -

(a) 0.36° (b) 0.18°
(c) 0.72° (d) 0.09°

Q.7 A screen is placed 2m away from the single narrow slit. Calculate the slit width if the first minimum lies 5mm on either side of the central maximum. Incident plane waves have a wavelenght of 5000Å.

(a) 2×10^{-4} m (b) 2×10^{-3} cm
(c) 2×10^{-4} cm (d) None

Q.8 Red light of wavelength 6500Å from a distant source falls on a slit 0.5 mm wide. What is the distance between two dark bands on each side of central bright band of diffraction pattern observed on a screen placed 1.8 m from the slit.

(a) 4.68×10^{-3} cm (b) 4.68×10^{-3} mm
(c) 4.68×10^{-3} nm (d) 4.68×10^{-3} m

Q.9 Fraunhoffer diffraction pattern is observed at a distance of 2m on screen, when a plane-wavefront of 6000Å is incident perpendicularly on 0.2 mm wide slit.Width of central maxima is:

(a) 10 mm (b) 6 mm
(c) 12 mm (d) None of these

Q.10 A diffraction pattern is produced by a single slit of width 0.5mm with the help of a convex lens of focal length 40cm. If the wavelength of light used is 5896Å. then the distance of first dark fringe from the axis will be-

(a) 0.047 cm (b) 0.047 m
(c) 0.047 mm (d) 47 cm

Q.11 What should be the size of the aperture of the objective of telescope which can just resolve the two stars of angular width of 10^{-3} degree by light of wavelength 5000Å?

(a) 3.5 cm (b) 3.5 mm
(c) 3.5 m (d) 3.5 km

Q.12 Image of sun formed due to reflection at air water interface is found to be very highly polarised. Refractive index of water being $\mu = 4/3$, find the angle of sun above the horizon.

(a) 36.9° (b) 26.9°
(c) 16.9° (d) 46.9°

Q.13 When light of a certain wavelength is incident on a plane surface of a material at a glancing angle 30°, the reflected light is found to be completely plane polarised. Determine refractive index of given material –

(a) $\sqrt{3}$ (b) $\sqrt{2}$
(c) $1/\sqrt{2}$ (d) 2

Q.14 Two polaroids are oriented with their planes perpendicular to incident light and transmission axis making an angle of 30° with each other. What fraction of incident unpolarised light is transmitted ?

(a) 57.5 % (b) 17.5 %
(c) 27.5 % (d) 37.5 %

Q.15 Unpolarised light of intensity 32 Wm^{-2} passes through three polarisers such that the transmission axis of the last polariser is crossed with the first. If the intensity of the emerging light is 3 Wm^{-2}. At what angle will the transmitted intensity be maximum ?

(a) 45° (b) 15°
(c) 35° (d) 75°

Q.16 V_0 and V_E represent the velocities, μ_0 and μ_E the refractive indices of ordinary and extraordinary rays for a doubly refracting crystal. Then

(a) $V_0 \geq V_E$, $\mu_0 \leq \mu_E$ if the crystal is calcite
(b) $V_0 \leq V_E$, $\mu_0 \leq \mu_E$ if the crystal is quartz
(c) $V_0 \leq V_E$, $\mu_0 \geq \mu_E$ if the crystal is calcite
(d) $V_0 \geq V_E$, $\mu_0 \geq \mu_E$ if the crystal is quartz

RESPONSE GRID					
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ				

Space for Rough Work

Q.17 A ray of light is incident on the surface of a glass plate at an angle of incidence equal to Brewster's angle ϕ. If μ represents the refractive index of glass with respect to air. then the angle between reflected and refracted rays is

(a) $90° + \phi$ (b) $\sin^{-1}(\mu \cos\phi)$

(c) $90°$ (d) $90° - \sin^{-1}(\cos\phi/\mu)$

Q.18 A light has amplitude A and angle between analyser and polariser is 60°. Light transmitted by analyser has amplitude

(a) $A\sqrt{2}$ (b) $A/\sqrt{2}$ (c) $\sqrt{3}A/2$ (d) A/2

Q.19 A slit of size 0.15 cm is placed at 2.1 m from a screen. On illuminating it by a light of wavelength 5×10^{-5} cm, the width of central maxima will be

(a) 70 mm (b) 0.14 mm (c) 1.4 mm (d) 0.14 cm

Q.20 What will be the angle of diffraction for the first minimum due to Fraunhoffer diffraction with sources of light of wave lenght 550 nm and slit width 0.55 mm ?

(a) 0.001 rad (b) 0.01 rad

(c) 1 rad (d) 0.1 rad

Q.21 In Fresnel diffraction, if the distance between the disc and the screen is decreased, the intensity of central bright spot will

(a) increase (b) decrease

(c) remain constant (d) none of these

22. When an unpolarized light of intensity I_0 is incident on a polarizing sheet, the intensity of the light which does not get transmitted is

(a) $\frac{1}{4}I_0$ (b) $\frac{1}{2}I_0$ (c) I_0 (d) zero

DIRECTIONS (Q.23-Q.25) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct

(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.23 Plane polarised light is passed through a polaroid. On viewing through the polaroid we find that when the polariod is given one complete rotation about the direction of the light, which of the following is not observed ?

(1) The intensity of light gradually decreases to zero and remains at zero

(2) The intensity of light gradually increases to a maximum and remains at maximum

(3) There is no change in intensity

(4) The intensity of light is twice maximum and twice zero

Q.24 Out of the following statements which are correct ?

(1) Nicol's prism works on the principle of double refraction and total internal reflection

(2) Nicol's prism can be used to produce and analyse polarised light

(3) Calcite and Quartz are both doubly refracting crystals

(4) When unpolarised light passes through a Nicol's prism, the emergent light is elliptically polarised

Q.25 Which statements are incorrect for a zone plate and a lens?

(1) Zone plate has one focus whereas lens has multiple focii

(2) Both zone plate and lens have multi focii

(3) Zone plate has one focus whereas a lens has infinite

(4) Zone plate has multi focii whereas lens has one

RESPONSE GRID					
	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ
	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	

Space for Rough Work

DIRECTIONS (Q.26-Q.27) : Read the passage given below and answer the questions that follows :

Angular width of central maximum in the Fraunhoffer-diffraction pattern of a slit is measured. The slit is illuminated by light of wavelength 6000 Å. When the slit is illuminated by light of another wavelength, the angular width decreases by 30%.

Q.26 The wavelength of the light is

(a) 4200Å (b) 3500Å (c) 5000 Å (d) 5200Å

Q.27 The same decrease in the angular width of central maximum is obtained when the original apparatus is immersed in a liquid. Find refractive index of the liquid.

(a) 1.23 (b) 1.43 (c) 2.2 (d) 2.43

DIRECTIONS (Q. 28-Q.30) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.

(c) Statement-1 is False, Statement-2 is True.

(d) Statement-1 is True, Statement-2 is False.

Q.28 **Statement-1 :** The unpolarised light and polarised light can be distinguished from each other by using polaroid.

Statement-2 : A polaroid is capable of producing plane polarised beams of light.

Q.29 **Statement-1 :** Nicol prism is used to produce and analyse plane polarised light.

Statement-2 : Nicol prism reduces the intensity of light to zero.

Q.30 **Statement-1 :** The cloud in sky generally appear to be whitish.

Statement-2 : Diffraction due to clouds is efficient in equal measure at all wavelengths.

RESPONSE GRID					
	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 53 - PHYSICS			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	26	Qualifying Score	46
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

53

1. **(b).** The distance of first diffraction minimum from the central principal maximum $x = \lambda D/d$

$$\therefore \sin\theta = \frac{x}{D} = \frac{\lambda}{d} \Rightarrow d = \frac{\lambda}{\sin\theta}$$

$$\Rightarrow d = \frac{5000\times10^{-8}}{\sin 30^o} = 2 \times 5 \times 10^{-5}$$

$\Rightarrow d = 1.0 \times 10^{-4}$ cm.

2. **(b).** Here, $\lambda_1 = 5890Å = 5890 \times 10^{-10}$ m

$\lambda_2 = 5896$ Å $= 5896 \times 10^{-10}$ m

a $=2\mu m = 2 \times 10^{-6}$ m, D = 2m

For first maxima, $\sin\theta = \frac{3\lambda_1}{2a} = \frac{x_1}{D}$

$$\Rightarrow x_1 = \frac{3\lambda_1 D}{2a} \text{ and } x_2 = \frac{3\lambda_2 D}{2a}$$

$\therefore$ spacing between the first maxima of two sodium lines

$$= x_2 - x_1 = \frac{3D}{2a}(\lambda_2 - \lambda_1)$$

$$= \frac{3\times2(5896-5890)\times10^{-10}}{2\times2\times10^{-6}} = 9 \times 10^{-4} \text{ m.}$$

3. **(d).** $\frac{ax}{f} = n\lambda$

$$\lambda = \frac{ax}{n.f} = \frac{0.3\times10^{-3}\times5\times10^{-3}}{3\times1}$$

$\lambda = 5 \times 10^{-7}$ m

$\lambda = 5000Å$

4. **(b).** $\theta = \sin^{-1}\left(\frac{\lambda}{a}\right)$ .....(1)

According to question

$\lambda = 2 \times 10^{-3}$ m

$a = 4 \times 10^{-3}$ m .....(2)

From equation (1) and (2)

$$\theta = \sin^{-1}\left(\frac{1}{2}\right)$$

$\theta = 30°$

5. **(a).** Here the width of principal maxima is 2.5 mm, therefore its half width is

$$\frac{\beta}{2} = \frac{2.5}{2} = 1.25 \times 10^{-3}\text{m}$$

Diffraction angle $\theta = \frac{\beta/2}{D} = \frac{12.5\times10^{-3}}{2}$

$\therefore a\,\theta = \lambda$

$$\theta = \lambda/a = \frac{12.5\times10^{-3}}{2}$$

$$\lambda = \frac{12.5\times10^{-3}}{2} \times a = \frac{12.5\times10^{-3}\times10^{-3}}{2}$$

$\lambda = 6.25 \times 10^{-6}$ m $= 6250$ mm

6. **(a).** Slit width = a = 0.2mm,

$$\beta = \frac{2\lambda d}{a}$$

Angular width $W_\theta = \frac{\beta}{D} = \frac{2\lambda}{a}$

$$\theta = \frac{2\times6328}{0.2} = 0.36°$$

7. **(a).** Here distance of the screen from the slit,

D = 2m, a = ?, x = 5 mm

$= 5 \times 10^{-3}$ m, $\lambda = 5000Å$

$= 5000 \times 10^{-10}$ m

For the first minima, $\sin\theta = \lambda/a = x/D$,

$$a = \frac{D\lambda}{x} = \frac{2\times5000\times10^{-10}}{5\times10^{-3}} = 2 \times 10^{-4} \text{ m}$$

8. **(d).** Here, $\lambda = 6500Å = 6.5 \times 10^{-7}$ m, a = 0.5 mm = 5×10^{-4} m,

D = 1.8 m

Angular separation of two dark bands on each side of central bright band $2\theta = 2\lambda/a$

Actual distance between them,

$2x = 2\lambda/a$ x D

$$2x = \frac{2\times6.5\times10^{-7}\times18}{5\times10^{-4}}$$

$2x = 4.68 \times 10^{-3}$ m

9. **(c).** Width of central maxima $= \frac{2f\lambda}{a}$

$$= \frac{2\times2\times6000\times10^{-10}}{0.2\times10^{-3}} = 12 \text{ mm}$$

10. **(a).** $\theta = \frac{\lambda}{a}$ .....(a)

$\theta = \frac{x}{f}$ .....(b)

From eqs. (a) and (b)

$$\frac{\lambda}{a} = \frac{x}{f}$$

$x = \frac{f\lambda}{a}$ .....(c)

According to question x = ?, f = 40 cm

$\lambda = 5896 \times 10^{-8}$ cm

$a = 0.5 \times 10^{-1}$ cm .....(d)

From eqs. (c) and (d)

$$x = \frac{40 \times 5896 \times 10^{-8}}{5 \times 10^{-2}} 96 = 0.047\text{cm}$$

11. **(a).** $d\theta = \frac{1.22\lambda}{a}$ or $a = \frac{1.22\lambda}{d\theta}$

According to question

$$d\theta = 10^{-3} \text{ degree} = \frac{10^{-3} \times \pi}{180} \text{ Radian,}$$

$\lambda = 5 \times 10^{-5}$

$$a = \frac{1.22 \times 5 \times 10^{-5} \times 180}{10^{-3} \times 3.14}$$

a = 3.5 cm

12. **(a).** Since the reflected light is very highly polarised, it implies that incident light falls at polarising angle of incidence θ_P. From Brewster's law,

$\mu = \tan\theta_p$

$\therefore$ $\theta_P = \tan^{-1}(\mu) = \tan^{-1}(4/3) = 53.1°$

Since θ_P is the angle which the rays from sun make with the normal to the interface, angle with the interface will be 90° – 53.1° = 36.9°.

13. **(a).** Angle of incident light with the surface is 30°. Hence angle of incidence = 90° – 30° = 60°. Since reflected light is completely polarised, therefore, incidence takes place at polarising angle of incidence θ_p.

$\therefore$ $\theta_p = 60°$

Using Brewster's law

$\mu = \tan\theta_p = \tan 60°$

$\therefore$ $\mu = \sqrt{3}$

14. **(d).** If unpolarised light is passed through a polariod P_1, its intensity will become half.

So $I_1 = \frac{1}{2} I_0$ with vibrations parallel to the axis of P_1.

Now this light will pass through second polaroid P_2 whose axis is inclined at ana angle of 30° to the axis of P_1 and hence, vibrations of I_1. So in accordance with Malus law, the intensity of light emerging from P_2 will be

$$I_2 = I_1 \cos^2 30° = \left(\frac{1}{2}I_0\right)\left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{8}I_0$$

$$\frac{I_2}{I_0} = \frac{3}{8} = 37.5\ \%$$

15. **(a).** If θ is the angle between the transmission axes of first polaroid P_1 and second P_2 while ϕ between the transmission axes of second polaroids P_2 and P_3, then according to given problem,

$\theta + \phi = 90°$ or $\phi = (90° - \theta)$ ....(1)

Now, if I_0 is the intensity of unpolarised light incident on polaroid P_1, the intensity of light transmitted through it,

$$I_1 = \frac{1}{2}I_0 = I_0 = \frac{1}{2}(32) = 16\frac{W}{m^2} \quad ....(2)$$

Now as angle between transmission axes of polaroids P_1 and P_2 is θ, in accordance with Malus law, intensity of light transmitted through P_2 will be

$I_2 = I_1 \cos^2\theta = 16 \cos^2\theta$ [from Eq. (2)] ....(3)

And as angle between transmission axes of P_2 and P_3 is ϕ, light transmitted through P_3 will be

$I_3 = I_2\cos^2\phi = 16 \cos^2\theta \cos^2\phi$ [from Eq.(3)]

Above equation in the light of (1) becomes,

$I_3 = 16 \cos^2\theta \cos^2(90° - \theta) = 4(\sin 2\theta)^2$ ....(4)

According to given problem, $I_3 = 3\ W/m^2$

So, $4(\sin 2\theta)^2 = 3$ i.e., $\sin 2\theta = (\sqrt{3}/2)$

or $2\theta = 60°$ i.e. $\theta = 30°$

Further in accordance with Eq. (4), I_3 will be max. when $\sin 2\theta$ = max., i.e.,

$\sin 2\theta = 1$ or $2\theta = 90°$, i.e., $\theta = 45°$

16. **(c)** In double refraction light rays always splits into two rays (O–ray & E–ray). O–ray has same velocity in all direction but E– ray has different velocity in different direction.

For calcite $\mu_e < \mu_0 \Rightarrow v_e > v_0$

For quartz $\mu_e > \mu_0 \Rightarrow v_0 > v_e$

17. **(c)** At polarizing angle, the reflected and refracted rays are mutually perpendicular to each other.

18. **(d)** The amplitude will be A cos60° = A/2

19. **(c)** Width of central maxima $= \frac{2\lambda D}{d}$

$$= \frac{2 \times 2.1 \times 5 \times 10^{-7}}{0.15 \times 10^{-2}} = 1.4 \times 10^{-3} \text{ m} = 1.4 \text{ mm}$$

20. **(a)** Using $d \sin\theta = n\lambda$, for n = 1

$$\sin\theta = \frac{\lambda}{d} = \frac{550 \times 10^{-9}}{0.55 \times 10^{-3}} = 10^{-3} = 0.001 \text{ rad}$$

21. **(b)** $A = n\pi\, d\lambda \Rightarrow nd = \frac{A}{\pi\lambda} = \text{constant} \Rightarrow n \propto \frac{1}{d}$

(n = number of blocked HPZ) on decreasing d, n increases, hence intensity decreases.

22. **(b)** Intensity of polarized light $= \frac{I_0}{2}$

$\Rightarrow$ Intensity of untransmitted light $= I_0 - \frac{I_0}{2} = \frac{I_0}{2}$

23. **(a)**

24. **(a)** It magnitude of light vector varies periodically during it's rotation, the tip of vector traces an ellipse and light is said to be elliptically polarised. This is not in nicol prism.

25. **(a)** Multiple focii of zone plate given by $f_p = \frac{r_n^2}{(2p-1)\lambda}$,

where p = 1, 2, 3 ....

26. **(a)** Angular width is the angle subtended by the distance between first minima on either side at the centre of the slit. It is given by $\phi = 2\,\theta$, where θ is the angle of diffraction.

For first diffraction minimum, $a \sin\theta = 1\lambda$

or $\sin\theta = \lambda/a$ or $\theta = \frac{\lambda}{a}$

$\therefore$ Angular width $\phi = 2\theta = \frac{2\lambda}{a}$ i.e. $\phi \propto \lambda$

$$\frac{\phi_1}{\phi_2} = \frac{\lambda_1}{\lambda_2}; \ \therefore \ \lambda_2 = \lambda_1 \frac{\phi_2}{\phi_1} = 6000 \times \frac{70}{100} = 4200\,\text{Å}$$

27. **(b)** On immersing in liquid, a wavelength $\lambda = 6000$ Å must be behaving as $\lambda' = 4200$ Å to get the same decrease in angular width. Therefore, refractive index of medium

$$\mu = \frac{\lambda}{\lambda'} = \frac{6000}{4200} = 1.43.$$

28. **(a)** When a polaroid is rotated in the path of unpolarised light, the intensity of light transmitted from polaroid remains undiminished (because unpolarised light contains waves vibrating in all possible planes with rotated in path of plane polarised light, its intensity will vary from maximum (when the vibrations of the plane polarised light are parallel to the axis of the polaroid) to minimum (when the direction of the vibrations becomes perpendicular to the axis of the crystal). Thus using polaroid we can easily verify that whether the light is polarised or not.

29. **(d)** The nicol prism is made of calcite crystal. When light is passed through calcite crystal, it breaks up into two rays

(i) the ordinary ray which has its electric vector perpendicular to the principal section of the crystal and

(ii) the extra ordinary ray which has its electric vector parallel to the principal section. The nicol prism is made in such a way that it eliminates one of the two rays by total internal reflection, thus produces plane polarised light. It is generally found that the ordinary ray is eliminated and only the extra ordinary ray is transmitted through the prism. The nicol prism consists of two calcite crystal cut at - 68° with its principal axis joined by a glue called Canada balsam.

30. **(d)** The clouds consists of dust particles and water droplets. Their size is very large as compared to the wavelength of the incident light from the sun. So there is very little scattering of light. Hence the light which we receive through the clouds has all the colours of light. As a result of this, we receive almost white light. Therefore, the cloud are generally white.