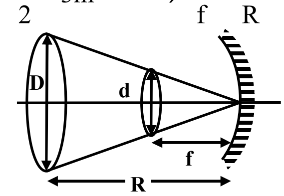
+2 TEST (Ray Optics & Wave Optics)

SOLUTIONS **Date: 03.11.2018** **TEST CODE–2429**

Q.No.	Set A	Set B	Set C	Set D
1	Q.49/D	Q.21/D	Q.55/B	Q.22/C
2	Q.31/A	Q.49/B	Q.35/C	Q.32/D
3	Q.25/B	Q.22/D	Q.25/C	Q.34/B
4	Q.57/C	Q.6/B	Q.4/C	Q.40/A
5	Q.14/C	Q.24/A	Q.34/C	Q.44/A
6	Q.9/B	Q.16/D	Q.49/B	Q.28/A
7	Q.8/C	Q.7/D	Q.33/A	Q.29/C
8	Q.30/D	Q.9/B	Q.46/A	Q.39/B
9	Q.41/C	Q.35/A	Q.38/D	Q.15/A
10	Q.52/A	Q.52/C	Q.19/C	Q.8/A
11	Q.45/A	Q.31/D	Q.32/A	Q.35/A
12	Q.39/B	Q.12/D	Q.39/A	Q.12/D
13	Q.46/B	Q.17/B	Q.47/D	Q.9/A
14	Q.15/C	Q.39/A	Q.20/D	Q.49/A
15	Q.38/D	Q.19/A	Q.16/D	Q.25/C
16	Q.47/B	Q.30/D	Q.48/D	Q.37/D
17	Q.26/A	Q.14/A	Q.5/D	Q.7/D
18	Q.7/C	Q.23/D	Q.21/D	Q.53/C
19	Q.29/B	Q.54/A	Q.7/D	Q.43/D
20	Q.37/B	Q.13/C	Q.11/C	Q.45/C
21	Q.44/C	Q.36/C	Q.51/B	Q.23/B
22	Q.12/B	Q.18/C	Q.31/B	Q.48/A
23	Q.22/A	Q.32/B	Q.18/C	Q.55/C
24	Q.40/D	Q.10/D	Q.10/B	Q.38/D
25	Q.21/C	Q.40/D	Q.9/A	Q.50/D
26	Q.23/A	Q.5/D	Q.44/D	Q.47/A
27	Q.32/A	Q.27/C	Q.28/B	Q.17/D
28	Q.18/A	Q.41/A	Q.26/B	Q.20/B
29	Q.58/D	Q.53/B	Q.15/D	Q.46/A
30	Q.20/B	Q.29/A	Q.12/A	Q.52/C
31	Q.43/C	Q.44/A	Q.27/A	Q.31/C
32	Q.48/D	Q.43/B	Q.14/B	Q.11/B
33	Q.53/A	Q.25/B	Q.17/B	Q.10/C
34	Q.24/A	Q.45/A	Q.54/A	Q.41/A
35	Q.17/C	Q.47/B	Q.45/D	Q.51/A
36	Q.13/A	Q.8/B	Q.42/A	Q.54/A
37	Q.50/C	Q.37/C	Q.29/A	Q.33/C
38	Q.56/B	Q.15/C	Q.43/C	Q.19/B
39	Q.16/C	Q.42/D	Q.40/A	Q.21/C
40	Q.54/A	Q.55/D	Q.22/A	Q.14/B
41	Q.10/B	Q.4/C	Q.24/C	Q.36/A
42	Q.55/D	Q.50/D	Q.53/D	Q.16/B
43	Q.27/D	Q.34/D	Q.8/B	Q.24/D
44	Q.33/D	Q.26/A	Q.36/D	Q.5/C
45	Q.34/C	Q.11/B	Q.50/A	Q.42/B
46	Q.35/C	Q.38/A	Q.30/B	Q.13/C
47	Q.11/B	Q.20/A	Q.6/B	Q.6/B
48	Q.36/D	Q.48/C	Q.23/C	Q.27/C
49	Q.28/D	Q.51/A	Q.37/D	Q.18/C
50	Q.51/C	Q.46/D	Q.41/C	Q.4/B
51	Q.19/C	Q.28/B	Q.52/D	Q.26/B
52	Q.42/D	Q.33/D	Q.13/B	Q.30/B
53	Q.1/C	Q.1/A	Q.56/A	Q.56/B
54	Q.2/B	Q.2/D	Q.57/A	Q.57/C
55	Q.3/C	Q.3/D	Q.58/D	Q.58/D
56	Q.4/C	Q.56/C	Q.1/A	Q.1/A
57	Q.5/A	Q.57/B	Q.2/B	Q.2/C
58	Q.6/D	Q.58/D	Q.3/B	Q.3/C

[JEE MAINS LEVEL]

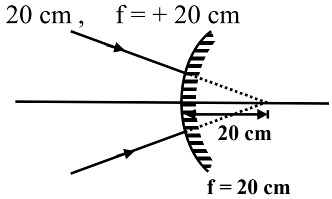
1. (A) $f = \frac{R}{2} = \frac{6}{2} = 3m \quad \Rightarrow \frac{d}{f} = \frac{D}{R}$



$$d = \frac{Df}{R} = \frac{864100\times 3}{9290000} = 0.027m$$

$= 27$ mm

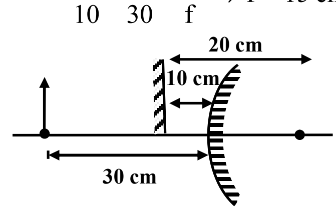
2. (A) u = + 20 cm , f = + 20 cm



$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \quad \Rightarrow \frac{1}{v}+\frac{1}{20}=\frac{1}{20} \quad \Rightarrow \frac{1}{v}=0 \quad \Rightarrow v=\infty$$

3. (B) u = – 30, v = 10 cm

$$\frac{1}{10}-\frac{1}{30}=\frac{1}{f} \Rightarrow f = 15 \text{ cm}$$

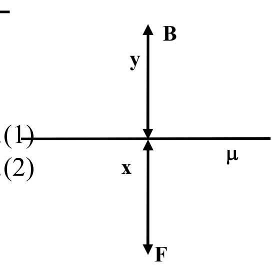


4. (C) $s_1 = y + x/\mu$

$\Rightarrow \mu s_1 = \mu y + x$ …(1)

$s_2 = x + \mu y$ …(2)

from (1) & (2)



$\mu s_1 = s_2 \Rightarrow \mu = \frac{s_2}{s_1}$

5. (B) $\mu = \frac{\delta_m\left(\frac{A+\delta_m}{2}\right)}{\delta_m(A/2)}$, put $\delta_m = 180 - 2A$

6. (D) $r_1 = \theta_c \quad \Rightarrow \delta_m\, r_2 = 1/\mu = 1/\sqrt{2} \quad \Rightarrow r_2 = 45$

$A = r_1 + r_2 \quad \Rightarrow r_1 = A - r_2 = 75 - 45 = 30$

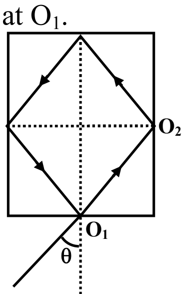
$\delta_m i = \mu \delta_m r_1 = \sqrt{2} \times \sin 30^\circ = \frac{1}{\sqrt{2}}$

$i = 45^\circ$

7. (A) $i_1 = i_2 = 60^\circ$, $\quad A = 60^\circ$

$\delta_m = i_1 + i_2 - A = 60^\circ + 60^\circ - 60^\circ = 60^\circ$

8. (D) The ray will strike at O_1 again after internal reflections, if angle of refraction at O_1 is 45^0 Snell's law at O_1.



$\sin\theta = \mu \sin 45^0 = \mu/\sqrt{2}$

For internal reflection at O_2. $\quad i > \theta_C$

$\sin i > \sin \theta_C$

$\sin i > \frac{1}{\mu}$

Ray will strike again at O_1 after internal reflection, if $\angle i = 45^0$

$\sin 45^0 > \frac{1}{\mu} \quad \Rightarrow \quad \frac{1}{\sqrt{2}} > \frac{1}{\mu}$, or $\mu > \sqrt{2}$

Critically $\mu = \sqrt{2}$

From equation (i), $\sin\theta = \frac{\mu}{\sqrt{2}} = \frac{\sqrt{2}}{\sqrt{2}} = 1$

$\theta = 90^0$

9. (B) The image is erect and magnified. The mirror is concave

$m = \frac{I}{O} = -\frac{v}{u} \quad \Rightarrow \quad \frac{6}{1} = -\frac{v}{(-u)}$

$v = +6u$

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad \Rightarrow \quad \frac{1}{6u} + \frac{1}{(-u)} = \frac{1}{f}$

$f = -\frac{6u}{5}$

$f - u = -\frac{6u}{5} - (-u) = -\frac{u}{5}$

$|f - u| = \frac{u}{5}$

10. (C) The mirror will be convex because image is erect and diminished. MM_1 will be the position of mirror.

$OO_1 = 2II_1$

Join I and F and produce.

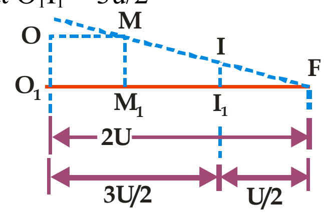
Draw OM parallel to O_1F,

Draw MM_1 perpendicular to O_1F,

$\frac{MM_1}{II_1} = \frac{OO_1}{II_1} = 2 = \frac{M_1F}{I_1F}$ .... (i)

Given $O_1F = 2u$ and $\frac{O_1I_1}{I_1F} = 3$

So, that $O_1I_1 = 3u/2$



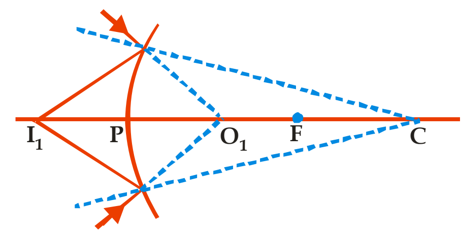
and $I_1F = u/2$

From eqn. (i)

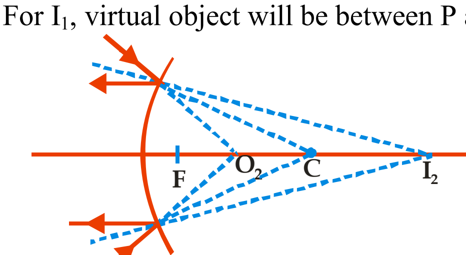
$M_1F = 2I_1F = u$

and $O_1M_1 = O_1F - M_1F = u$

11. (B)



For I_1, virtual object will be between P and F



For I_2, virtual object will be between F and C

12. (D) **For A**

$u = -3$ m $v_1 = ?$, $f = -1$ m

$\frac{1}{u_1} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-1} - \frac{1}{-3} = \frac{1}{3} - 1 = -\frac{2}{3}$

or $\quad v_1 = -\frac{3}{2}$

For B

$\frac{1}{v_2} = \frac{1}{-1} - \frac{1}{-5}$ or $\frac{1}{v_2} = \frac{1}{5} - 1 = -\frac{4}{5}$

or $\quad v_2 = -\frac{5}{4}$ m

Now, $\quad v_1 - v_2 = \frac{3}{2} - \left(-\frac{5}{4}\right)$

$= -\frac{3}{2} + \frac{5}{4} = -\frac{1}{4}$ m $= -0.25$ m

Again, $\frac{I_1}{Q} = -\frac{v_1}{u}$

or $I_1 = -\frac{v_1}{u}O = -\left(\frac{-3}{2}\right)\left(\frac{-1}{3}\right) = -1\text{ m}$

Again, $\frac{I_2}{O} = -\frac{v_2}{u}$

or $I_2 = -\left(-\frac{5}{4}\right)\left(\frac{1}{-5}\right)2 = -0.5\text{ m}$

13. (D) Mirror can be shifted to new position C′D′. Distances are shown in the figure below.

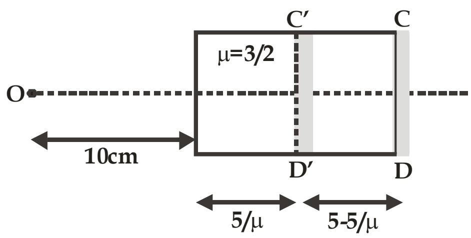


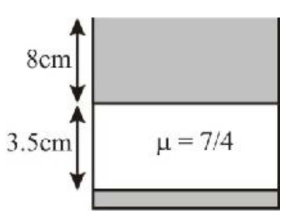
Image will be at equal distance from the mirror C′D′ as the object is.

Image distance from C′D′

$$= 10 + \frac{5}{3/2} = 10 + \frac{10}{3} = \frac{40}{3}\text{cm}$$

Separation between object and image is $\frac{80}{3}\text{cm}$.

14. (C)
Sol.



For class slab

$$\text{shift} = t\left(1 - \frac{1}{\mu R}\right)$$

$$= 3.5\left(1 - \frac{1}{\frac{7/4}{4/3}}\right) = x$$

For water surface
Depth = 8 + (3.5 – x)
So final image from surface

$$\Rightarrow \frac{\text{Real depth}}{\mu_\omega} = \frac{8 + (3.5 - x)}{4/3}$$

15. (C)
Sol. Lets bubble is x distance from 1st surface

So $10 = \frac{x}{\mu}$ … (1)

From 2nd surface

$$6 = \frac{2\mu - x}{\mu} \quad \text{…. (2)}$$

Solving (1) and (2) we get $\mu = 1.5$

16. (A)
Sol. As $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ …. (1)

Diff. w.r.t. time

$$-\frac{dv}{dt}\left(\frac{1}{v^2}\right) - \frac{du}{dt}\left(\frac{1}{u^2}\right) = 0$$

$$\frac{dv}{dt} = \frac{du}{dt}\left(\frac{v}{u}\right)^2 \quad \text{… (2)}$$

As from (1)

$$\frac{1}{v} - \frac{1}{30} = \frac{1}{20} \Rightarrow \frac{1}{v} = \frac{1}{10}\left(\frac{1}{2} + \frac{1}{3}\right) = \frac{5}{60}$$

V = 12 cm
So from 2nd

$$\frac{dv}{dt} = (1)\left[\frac{12}{30}\right]$$

17. (A)
Sol. From shells law
(1) sin 45 = μ sin 30°

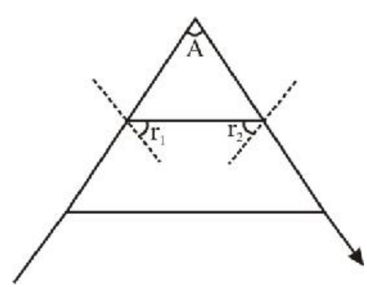
$$\mu = \frac{2}{\sqrt{2}} \Rightarrow \sqrt{2}$$

18. (B)

19. (D) $i_1 = i_2 = \frac{3}{4}A = \frac{3}{4} \times 60^\circ = 45^\circ$

$\delta = i_1 + i_2 - A = 45° + 45° - 60° = 30°$

20. (B)
Sol.



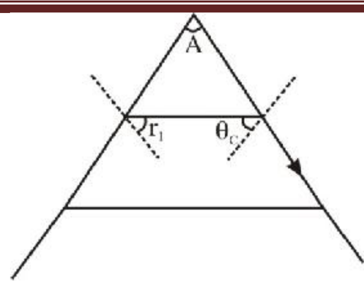
As i = e
So $r_1 = r_2$ = (r say)
r1 + r2 = A

$$r = \frac{A}{2} = 45^\circ$$

For 1st refraction
(1) sin 90 = (sin 45) μ

$$\mu = \sqrt{2}$$

21. (C)
Sol.



For 1st refraction

(1) sin 90 = μ sin r_1

$$\sin r_1 = \frac{1}{\mu}$$

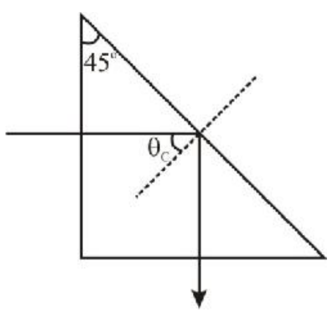
$$r_1 = \sin^{-1}\left(\frac{1}{\mu}\right)$$

Now $r_1 + \theta_C = A$ and $r_1 = \theta_C$

$$\text{So } A = 20r_1 \Rightarrow \sin^{-1}\left(\frac{1}{\mu}\right)$$

22. (C)

Sol.



As for i = 45°

It must be equal to θ_C TIR

$$\text{So } \sin 45 = \frac{1}{\mu}$$

$$\mu = \sqrt{2}$$

23. (D)

Sol. For 1st reflection

$\theta_1 = 60^\circ$

For 1st refraction

$$\frac{5}{3}(\sin 30) = \frac{4}{3}\sin\theta_2$$

$$\theta_2 = \sin^{-1}\left(\frac{5}{8}\right)$$

For TIR at P

$$\sin\theta_1 = \sin 60 = \frac{1}{\mu R}$$

$$\Rightarrow \frac{\sqrt{3}}{2} = \frac{1}{\mu_g / \mu_\omega}$$

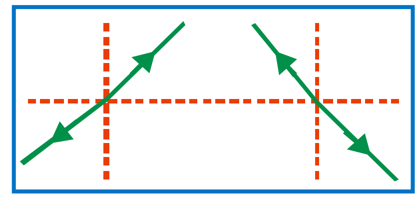
$$\frac{\sqrt{3}}{2} = \frac{\mu_\omega}{5/3} \Rightarrow \mu_\omega = \frac{5}{2\sqrt{3}}$$

24. (A)

Sol. For d (sin i) μ0 = sin μ

$$\frac{\sin i}{\sin r} = \frac{\mu}{\mu_0}$$

25. (A)



Since the refractive index is changing, the light cannot travel in a straight line in the liquid as shown in option (c) and (d). Initially, it will bend towards normal and after reflecting from the bottom it will bend away from the normal as shown in the figure.

26. (A) $\delta_m(\mu-1)A = (1.5-1)\frac{r}{2}$

[A = r/2] for min. dev.

$\Rightarrow \delta_m = r$

27. (C) $(\mu_1 - 1)A_1 = (\mu_2 - 1)A_2$

$\Rightarrow (1.54 - 1)\, 4^\circ = (1.72 - 1)\, A_2$

$\Rightarrow A_2 = 3^\circ$

28. (C) θ > C

$\Rightarrow 45^\circ > \sin^{-1} \Rightarrow \sin 45^\circ > 1/\mu$

$$\frac{1}{\sqrt{2}} > \frac{1}{\mu} \Rightarrow \mu > \sqrt{2}$$

SECTION – A

29. (C) $\Delta x = 2\mu t - \frac{\lambda}{2} = (2n-1)\frac{\lambda}{2}$

$2\mu t = n\lambda$

$$\lambda = \frac{2\mu t}{n} = \frac{2\times1.61\times0.5\times10^{-6}}{n} = \frac{1610}{n}\text{nm}$$

For n = 3, λ = 503 nm

For n = 4, λ = 402.5 nm

30. (C) $\frac{4\lambda_1 D}{d} = \frac{(2\times5-1)}{2}\frac{\lambda D}{d}$

Put λ_1 = 6300 Å to get λ = 5600 Å

31. (C) Apply $I = \frac{I_{\text{central maximum}}}{2}[1 + \cos\phi]$

$$\Rightarrow \frac{I_0}{2} = \frac{I_0}{2}[1+\cos\phi] \Rightarrow \cos\phi = 0 \Rightarrow \phi = \pi/2$$

Now $\phi = \frac{2\pi}{\lambda}\Delta x$, and $\Delta x = dy/D$

Solve to get $y = 7.2 \times 10^{-5}$ m

32. (B)

Sol. At midpoint of AB

Δx = 3λ

at ∞

Δx = 0

So on +ve x axis no of max = 3 on other side (-ve x axis) = 3.

Total = 6.

33. (B) $\frac{nD\lambda_r}{d} = \frac{(n+1)D\lambda_b}{d}$

$\Rightarrow \frac{n+1}{n} = \frac{78}{52} \Rightarrow n = 2$

34. (C) For (I) : $\Delta x = 2\mu t - \frac{\lambda}{2} = 2\times 1.4\times\frac{5\lambda}{4} - \frac{\lambda}{2} = 3\lambda$

So constructive interference

For (II): $\Delta x = 2\times 2\times\frac{3\lambda}{2} - \frac{\lambda}{2} = \frac{11\lambda}{2}$

So destructive interference

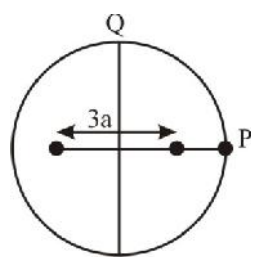
For (III): $\Delta x = 2\mu t = 2\times 2\times\frac{\lambda}{2} = 2\lambda$

So constructive interference.

35. (C) Slob will only produce shift.

36. (D)

Sol.



At P

$\Delta x = 3a$

At θ

$\Delta x = 0$

So in give circle.

No of maxima $= \frac{3a}{a/5} = 15$

For complex circle ⇒ m = 15 × 4 = 60.

37. (C) Shifting: $\delta = (\mu - 1)t\,D/d = \frac{30\lambda D}{d}$

$\Rightarrow t = \frac{30\lambda}{\mu - 1} = \frac{30\times 4800\times 10^{-10}}{1.6-1} = 2.4\times 10^{-5}$ m

38. (C) $y_n = n\left(\frac{D\lambda}{d}\right)$ and $y'_n = n'\left(\frac{D\lambda'}{d}\right)$

Equating y_n and y'_n, we get, $\frac{n}{n'} = \frac{\lambda'}{\lambda} = \frac{900}{750} = \frac{6}{5}$

Hence the first position at which overlapping occurs is

$y_6 = y' = \frac{6(2)(750\times 10^{-9})}{2\times 10^{-3}} = 4.5\text{mm}$

39. (C)

Sol. As $I_{max} = 4I_0$

Now for $I = 2I_0$

$2I_0 = I_0 + I_0 + 2\sqrt{I_0}\sqrt{I_0}\cos\phi$

$\cos\phi = 0$

$\phi = \frac{\pi}{2}$

$\Delta x = \frac{\lambda}{2\pi}\Delta\phi \Rightarrow \frac{\lambda}{2\pi}\times\frac{\pi}{2}$

$\Delta x = \frac{\lambda}{4}$ … (1)

For slab $\Delta x = t\left(1 - \frac{1}{\mu}\right)$ …. (2)

Solving (1) and (2) we get

$t = \frac{\lambda}{2}$

40. (B)

Sol. As $\frac{\beta}{D} = 2\times\frac{\pi}{180} = \frac{\pi}{90}$ and $\frac{\lambda D/d}{D} = \frac{\pi}{90}$

$\frac{\lambda}{d} = \frac{\pi}{90} = 0.035$

41. (C) **Let nth dark of** 400 nm coincides with mth dark of 600 nm, then we can get (for complete darkness)

4n + 2 = 6m + 3 ⇒ 4n = 6m + 1

odd ≠ even (not possible)

42. (A)

43. (D)

Sol. As $I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

Now $I_1 \neq I_2$

So $I_{min} \neq 0$

44. (C)

Sol. Path difference due to slab

$t\left(1 - \frac{1}{\mu_2/\mu_1}\right) \Rightarrow t\left(1 - \frac{\mu_1}{\mu_2}\right)$

Now $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$

$\Rightarrow \frac{2\pi}{\lambda}t\left(1 - \frac{\mu_1}{\mu_2}\right)$

45. (C)

Sol. For maxima at 0 difference of path difference due to slab = nλ

$t(\mu_1 - 1) - t(\mu_2 - 1) = n\lambda$ $t(\mu_1 - \mu_2) = n\lambda$

n = 2 ⇒ λ = 624 nm

n = 3 ⇒ λ = 416 nm

46. (A)

Sol. For minima at P

$\Delta\phi = (2n - 1)\pi$

47. (C) $2\mu t = n\lambda \Rightarrow t = \frac{\lambda}{2\mu} = \frac{500}{2\times 1.25} = 200$ nm

48. (B) $2\mu d = \left(\frac{2n-1}{2}\right) - \lambda \Rightarrow \lambda = \frac{4\mu d}{2n-1}$

$= \frac{4\times 1.4\times(10000)}{2n-1} = \frac{56000}{2n-1}$ Å

For n = 5, λ = 6222 Å , For n = 6, λ = 5091 Å

For n = 7, λ = 4308 Å

49. (A) $\beta \propto \lambda$, $\frac{\lambda_2}{\lambda_1} = \frac{\beta_2}{\beta_1} = 1.1$

$$\lambda_2 = 1.1\lambda_1 = 1.1 \times 5890 = 6479\ \mathring{A}$$

50. (C) $\frac{I_{max}}{I_{min}} = \left(\frac{3a+a}{3a-a}\right)^2 = 4:1$

51. (B) $\Delta x = \frac{by}{D} = \frac{b(b/2)}{D} = \frac{b^2}{2D}$

52. (C)

Sol. $\frac{I_1}{I_2} = \frac{25}{16}$

$$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}+1}\right)^2$$

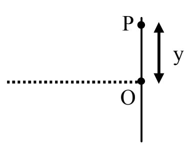
$$= \left(\frac{9}{1}\right)^2 = 81:1$$

53. (D) For point P on screen, path different between waves

$\Delta x = (S_2P - t + \mu t) - (S_1P + d\sin\theta)$

$\Rightarrow$ $\Delta x = (S_2P - S_1P) + (\mu - 1)t - d\sin\theta$

$\Rightarrow$ $\Delta x = \frac{dy}{D} + (\mu - 1)t - d\sin\theta$



For central maxima : $\Delta x = 0$

we can get any value of y (+ve , 0 or –ve) depending on values of other parameter.

54. (A) For central fringe to obtain at O

Put $\Delta x = 0$ and $y = 0 \Rightarrow (\mu - 1)\,t = d\sin\theta$

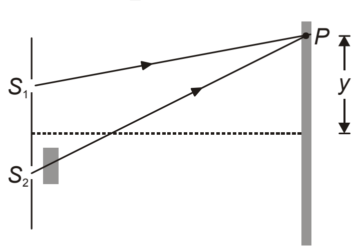
55. (B)

56. (C)

57. (C)

58. (A) Without inserting the slab, path difference at *P*,

$$\Delta x = \frac{yd}{D} = \frac{0.15\times10^{-3}\times2\times10^{-3}}{2} = 1.5\times10^{-7}\text{m}$$



Corresponding phase difference at *P*,

$$\phi = \left(\frac{2\pi}{\lambda}\right)(\Delta x) = \left(\frac{2\pi}{6000\times10^{-10}}\right)(1.5\times10^{-7}) = \frac{\pi}{2}$$

$\therefore$ $\frac{\phi}{2} = \frac{\pi}{4}$

$\therefore$ Intensity at *P*, $I = 4I_0\cos^2(\phi/2) = 2I_0$

Phase difference after placing the glass sheet,

$$\phi' = \phi + \frac{2\pi}{\lambda}(\mu - 1)t$$

$$= \frac{\pi}{2} + \frac{2\pi}{6000\times10^{-10}}(1.5-1)(8000\times10^{-10}) = \frac{11\pi}{6}$$

The intensity at *P* is now,

$I = I_0 + \eta I_0 + 2\sqrt{\eta I_0^2}\cos\frac{11\pi}{6} = 2I_0$ (given)

Solving this equation, we get $\eta = \frac{5-\sqrt{21}}{2}$