IIT – JEE: 2025 **TW TEST (ADV)** **DATE: 10/12/23**

ANSWER KEY

RAY OPTICS

1.	(A)	2.	(B)	3.	(A)	4.	(B)	5.	(A)
6.	(AC)	7.	(ABCD)	8.	(AC)	9.	(AC)	10.	(BCD)
11.	(AD)	12.	(A, B, C, D)	13.	(B, D)	14.	(B, C)	15.	(C)
16.	(9.00)	17.	(2.00)	18.	(6)	19.	(1)	20.	(1)

IUPAC NOMENCLATURE

21.	(C)	22.	(D)	23.	(D)	24.	(D)	25.	(C)
26.	(ABCD)	27.	(ABCD)	28.	(ACD)	29.	(ABC)	30.	(ABD)
31	(A)	32.	(BCD)	33.	(ABCD)	34.	(D)	35.	(ABD)
36.	(8.00)	37.	(0.00)	38.	(5.00)	39.	(3.00)	40.	(8.00)

PERMUTATIONS & COMBINATIONS

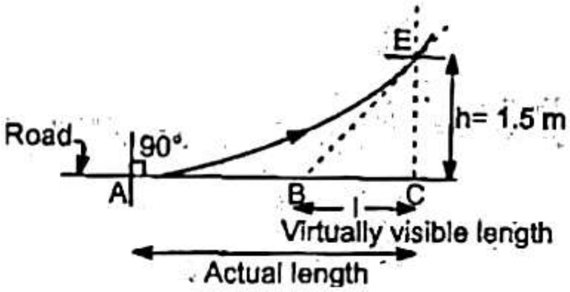
41.	(B)	42.	(C)	43.	(D)	44.	(A)	45.	(C)
46.	(ABC)	47.	(AB)	48.	(CD)	49.	(AC)	50.	(BCD)
51.	(ACD)	52.	(AC)	53.	(ABCD)	54.	(ABC)	55.	(BCD)
56.	(3720.00)	57.	(31.00)	58.	(7200.00)	59.	(135.00)	60.	(651.00)

IIT – JEE: 2025 **TW TEST (ADV)** **DATE: 10/12/23**

TOPIC: RAY OPTICS

SOLUTIONS

1. **(A)**



$$\mu_0 \sin 90^\circ = \mu_0 \left(1 + \frac{1.5}{3}\right) \sin\theta$$

$$\sin\theta = \frac{2}{3}$$

$$\cot\theta = \frac{\sqrt{5}}{2}$$

$$\cot\theta = \frac{h}{\ell}$$

$$\ell = \frac{h}{\cot\theta} = 1.5 \times \frac{2}{\sqrt{5}} = \frac{3}{\sqrt{5}}\,\text{m}$$

2. (B)

3. (A)

$$\delta = t\sin(i - r)\sec r$$

$$= \frac{t(\sin i \cos r - \sin r \cos i)}{\cos r}$$

$$= t(\sin i - \cos i \tan r)$$

$$= t(i - \tan r)$$

$$= t\left(i - \frac{i}{\mu}\right)$$

$$= t\left(\frac{\mu i - i}{\mu}\right)$$

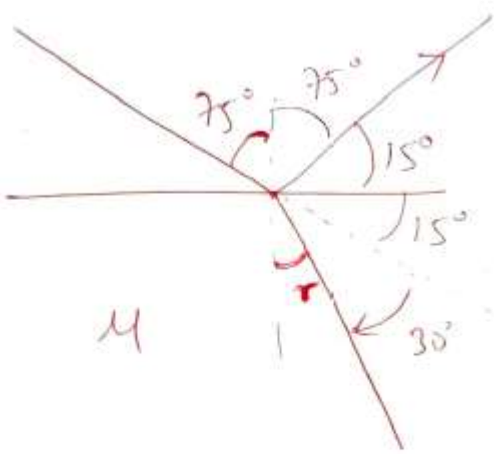
$$= t\theta(\mu - 1)$$

$1 = \mu \sin r$

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

$\Rightarrow \tan r = \frac{i}{\mu}$

4. (B)



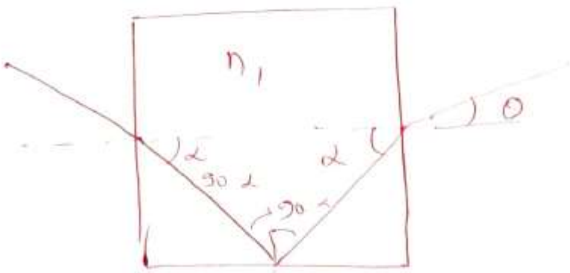
$s = 180 - 2i = 180 - 150 = 30°$

$r = 45°$

$1 \sin 75° = \mu \sin r$

$\mu = \frac{\sin 75°}{\sin 45°} = \frac{(\sqrt{3}+1)\sqrt{2}}{2\sqrt{2} \times 1} = \frac{\sqrt{3}+1}{2}$

5. (A)



$n_1 \sin \alpha = 1 \times \sin \theta$

$n_1 \sin(90 - \alpha) \geq n_2$

$\cos \alpha \geq \frac{n_2}{n_1} \Rightarrow \sin \alpha \leq \frac{\sqrt{n_1^2 - n_2^2}}{n_1}$

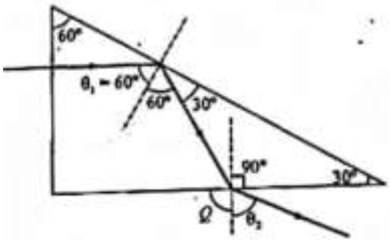
$\sin \theta = n_1 \sin \alpha$

$\sin \theta \leq n_1 \frac{\sqrt{n_1^2 - n_2^2}}{n_1}$

$\sin \theta < \sqrt{n_1^2 - n_2^2}$

6. **(AC)**

Using Snells law at point Q, we have



$$\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2$$

$$\Rightarrow \quad \frac{5}{3}\sin 30^o = \frac{4}{3}\sin\theta_2$$

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

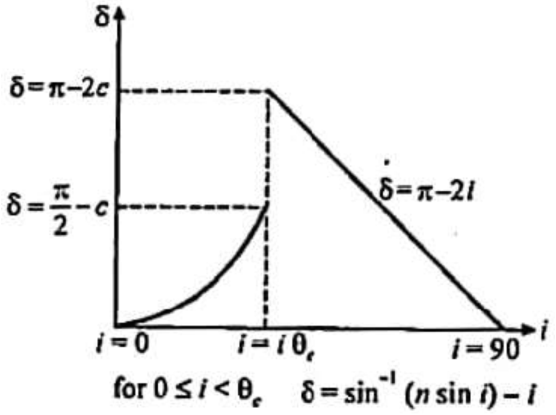
For total internal reflection at P, we use

$$\frac{5}{3}\sin 60^o = \mu_2 1$$

$$\Rightarrow \quad \mu_2 = \frac{5}{2\sqrt{3}}$$

7. **(ABCD)**

Figure explains how deviation angle varies with the incidence angle. With this figure we can analyze that all given options are correct.



8. **(AC)**

For convex mirror always $|m| < 1$ for any real object

As we know that $V_{image} = -m^2 V_{object}$

$$\Rightarrow \quad |V_{image}| < |V_{object}|$$

9. **(AC)**

A concave or convex mirror is to be placed left of the object. The object and the image both will be real for concave mirror and virtual for convex mirror.

10. **(BCD)**

Given that angle of incidence $= 60^o$

When $k = k_0$ we can see that $\theta = 0 \Rightarrow \angle i = \angle r$

Using Snell's law we have

$$\mu_1 \sin i = \mu_2 \sin r$$

If $i = r$

$\Rightarrow \quad \mu_1 = \mu_2$

$\Rightarrow \quad \frac{\mu_1}{\mu_2} = 1$

$\Rightarrow \quad k_0 = 1$

Before k_1 i.e. $k < k_1$ value of $\theta = 0$

So this is the condition of total internal reflection

So $\sin\theta_C = \frac{\mu_1}{\mu_2} = \sin\frac{\pi}{3}$

$\Rightarrow \quad k_1 = \frac{\mu_1}{\mu_2} = \frac{\sqrt{3}}{2}$

Value of $\theta_1 = |r - i| = \left|90^o - 60^o\right| = \frac{\pi}{6}$

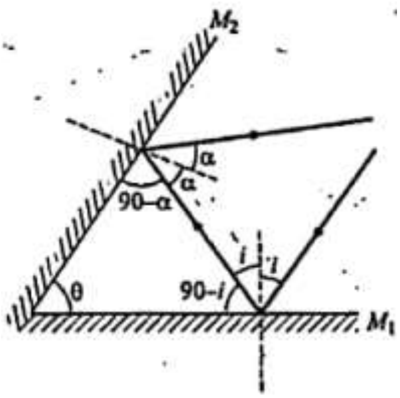
When $k = \infty$ then $\theta = \theta_2$ in this situation after refraction ray will travel along the normal.

So, we have $\quad i = \frac{\pi}{3} \quad r = 0$

$\Rightarrow \quad \theta_2 = |r - i| = \left|0 - \frac{\pi}{3}\right| = \frac{\pi}{3}$

11. (AD)

If the angle between the two plane mirror be θ, the light ray incident at angle i and angle α on mirror $M_1 \& M_2$ respectively as shown in figure below.



The deviation of light ray due to M_1 is $\delta_1 = 180^o - 2i$

And the deviation of light ray due to M_2 is $'\delta_2' = 180^o - 2\alpha$

Total deviation $\delta = \delta_1 + \delta_2 = 360^o - 2(i + \alpha)$

But $\theta + (90 - i) + (90 - \alpha) = 180^o$

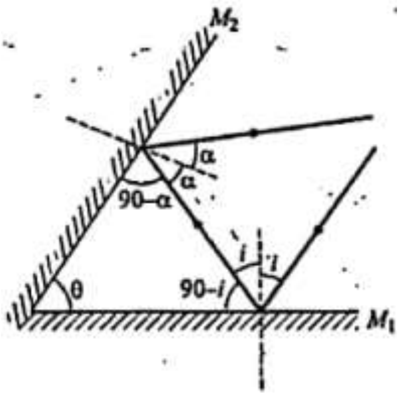
As we use from figure

$$i + \alpha = \theta$$

$\Rightarrow \quad \delta = 360^o - 2\theta$

12. (A, B, C, D)

If the angle between the two plane mirror be θ, the light ray incident at angle i and angle α on mirror $M_1 \& M_2$ respectively as shown in figure below.



The deviation of light ray due to M_1 is $\delta_1 = 180^o - 2i$

And the deviation of light ray due to M_2 is $'\delta_2' = 180^o - 2\alpha$

Total deviation $\delta = \delta_1 + \delta_2 = 360^o - 2(i + \alpha)$

But $\theta + (90 - i) + (90 - \alpha) = 180^o$

As we use from figure

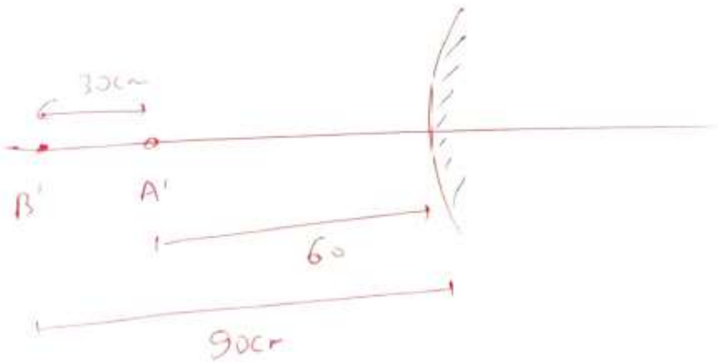
$i + \alpha = \theta$

$\Rightarrow \quad \delta = 360^o - 2\theta = 240 \Rightarrow \theta = 60°$

$\therefore$ Therefore number of image is $\frac{360}{60} - 1 = 5$

13. (B, D)

14. (B, C)



For A: $\frac{1}{v} + \frac{1}{-60} = \frac{1}{60}$

$v = 30$

For B: $\frac{1}{v} + \frac{1}{-90} = \frac{1}{60}$

$\frac{1}{v} = \frac{1}{60} + \frac{1}{90} = \frac{5}{180} \Rightarrow 36 = v$

Size of image = 36 – 30 = 6

15. (C)

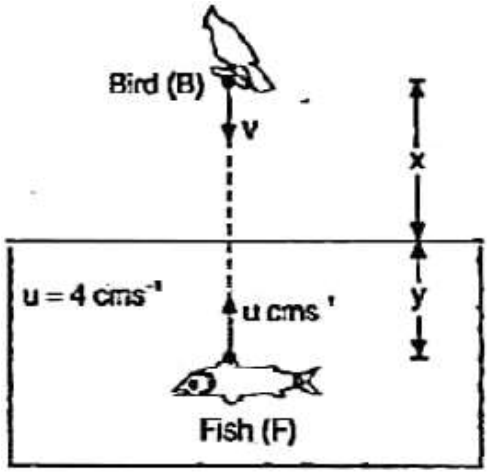
16. **(9.00)**

Let at some instant bird is at a height of x from the water surface and it is diving downwards with $v\,cms^{-1}$

At this instant fish is at a depth y below water surface. Then the distance between fish and image of bird at this instance will be,

$$S = \mu x + y$$

$$\Rightarrow \quad S = \frac{4}{3}x + y\,.$$



Differentiating w.r.t. time, we get

$$\left(-\frac{ds}{dt}\right) = \frac{4}{3}\left(-\frac{dx}{dt}\right) + \left(-\frac{dy}{dt}\right)$$

$$\Rightarrow \quad 16 = \frac{4}{3}(v) + u\text{, where } u = 4\,cms^{-1}$$

$$\Rightarrow \quad v = 9\,cms^{-1}$$

17. **(2.00)**

$$\sin\theta = n\sin r_1$$

$$\Rightarrow \quad 0 = n\cos r_1\frac{dr_1}{dn} + \sin r_1$$

$$\Rightarrow \quad \frac{dr_1}{dn} = -\frac{\sin r_1}{n\cos r_1}$$

Also, $r_2 + r_1 = A$

$$\Rightarrow \quad \frac{dr_2}{dn} = -\frac{dr_1}{dn} = \frac{\tan r_1}{n}$$

Also, $n\sin r_2 = \sin\theta$

$$1\times\sin r_2 + n\cos r_2\frac{dr_2}{dn} = \cos\theta\frac{d\theta}{dn}$$

$$\Rightarrow \quad \sin r_2 + n\cos r_2\times\left(\frac{\sin r_1}{n\cos r_1}\right) = \cos\theta\frac{d\theta}{dn}$$

$$\Rightarrow \quad \left(\frac{1}{2} + \frac{1}{2}\right) = \frac{1}{2}\frac{d\theta}{dn}$$

$$\frac{d\theta}{dn} = 2$$

18. (6)

For refraction

$$\frac{1.2}{V}-\frac{4}{3(-90)}=0$$

$$\therefore V=-\frac{1.2\times 3\times 90}{4}$$

= 81 cm

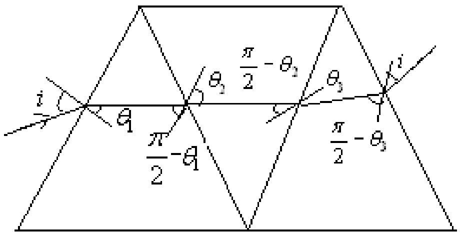
For reflection

$u = 81 + 69 = 150\ cm$

$\therefore\ V = 150\ cm$

$\therefore\quad 4V = 600\ cm\ = 6m$

19. (1)



$1\sin i = \mu_1 \sin\theta_1$

$\mu_1 \cos\theta_1 = \mu_2 \sin\theta_2$

$\mu_2 \cos\theta_2 = \mu_3 \sin\theta_3$

$\mu_3 \cos\theta_3 = i \sin i$

Squaring and rearranging will give

$\mu_1^2 + \mu_3^2 - \mu_2^2 = 1$

20. (1)

$\text{Sini} = \mu \sin r_1$

$$2^0 = \frac{3}{2}\times r_1$$

$$r_1 = \frac{4^0}{3}$$

$r_1 + r_2 = A$

$r_2 = A - r_1$

$$r_2 = \frac{8^0}{3}$$

$$\frac{3}{2}\sin r_2 = \frac{4}{3}\sin e$$

$$e = \frac{9}{8}r^2 = 3^0$$

$\delta = i + e - A$

$= 2^0 + 3^0 - 4^0$

$\delta = 1^0$

IIT – JEE: 2025 **TW TEST (ADV)** **DATE: 10/12/23**

TOPIC: PERMUTATION & COMBINATIONS

SOLUTION

41. **(B)**

Let A_1 be the property that HIN appears

Let A_2 be the property that DUS appears

Let A_3 be the property that TAN appears

$n(A_1) = 7! = 5040$

$n(A_2) = \frac{7!}{2!} = 2520$

$n(A_3) = 7! = 5040$

$n(A_1 \cap A_2) = n(A_2 \cap A_3) = n(A_3 \cap A_1) = 5! = 120$

$n(A_1 \cap A_2 \cap A_3) = 3! = 6$

$n(A_1 \cup A_2 \cup A_3) = \sum n(A_i) - \sum_{i \neq j} n(A_i \cap A_j) + n(A_1 \cap A_2 \cap A_3) = 12246$

Total number of ways to arrange the letters of the word HINDUSTAN $= \frac{9!}{2!} = 181440$

$\therefore$ Number of ways in which neither the pattern HIN or DUS and TAN appears
= 181440 – 12246 = 169194

42. **(C)**

Each object can be put either in box B_1 (say) or in box B_2(say). So, there are two choices for each of the n objects. Therefore the number of choices for n distinct objects is $\underbrace{2 \times 2 \times .... \times 2}_{n-\text{times}} = 2^n$. Two of these choices correspond to either the first or the second box being empty. Thus, there are $2^n - 2$ ways in which neither box is empty.

43. **(D)**

The number of triangles
= Total number of triangles
– Number of triangles having one side common with the octagon
– Number of triangles having two sides common with the octagon
$= {}^8C_3 - {}^8C_1 \times {}^4C_1 - 8 = 16$.

44. **(A)**

Let x_i denotes the marks assigned to the 8 question.

Then, $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 = 30$, where $x_i \geq 2$, $i = 1, 2, \ldots\ldots, 8$.

Let $y_i = x_i - 2$, $i = 1, 2, \ldots.., 8$. Then,

$y_1 + y_2 + y_3 + \ldots\ldots. + y_8 = 14$

The total number of solutions of this equation is ${}^{14+8-1}C_{8-1} = {}^{21}C_7$.

45. **(C)**

$x + y + 3z = 33 \Rightarrow x + y = 33 - 3z$

Let $z = k$. Then, $x + y = 33 - 3k$.

The number of non-negative integral solutions of $x + y = 33 - 3z$ is

${}^{33-3k+2-1}C_{2-1} = {}^{34-3k}C_1 = (34 - 3k)$

But $0 \le 33 - 3k \le 33 \Rightarrow 0 \le k \le 11$

Hence, total number of solutions = $\sum_{k=0}^{11}(34-3k) = \frac{12}{2}(34+1) = 210$.

46. **(ABC)**

Given $T_r = r(r\,!) = (r+1)\,! - r\,!$

$\Rightarrow \quad S = \sum T_r = (n+1)\,! - 1 \Rightarrow S + 1 = (n+1)\,!$

47. **(AB)**

48. **(CD)**

Required number = $4^n + {}^nC_2 4^{n-2} + {}^nC_4 4^{n-4} + \ldots\ldots$

$= \frac{1}{2}[(4+1)^n + (4-1)^n] = \frac{5^n + 3^n}{2}$

49. **(AC)**

Total hand shakes possible = ${}^{2n}C_2$

This will include n hand shakes in which a person shakes hand with her or his spouse.

$\Rightarrow$ Required number = ${}^{2n}C_2 - n = 2n(n-1)$

50. **(BCD)**

Since 210 = 2.3.5.7 the number of solutions must be same as number of ways of distributing 4 distinct object (given primes 2, 3, 5, 7) is 4 boxes $x_1x_2x_3x_4$

Thus number of solutions = 4^4

51. **(ACD)**

Conceptual

52. **(AC)**

Conceptual

53. **(ABCD)**

N is divisible by four distinct prime numbers.

First and second prizes in Mathematics (Physics) can be awarded in ${}^{30}P_2\left({}^{30}P_2\right)$ ways. First prize in Chemistry (Biology) can be awarded in 30 (30) ways.

Therefore, $N = \left({}^{30}P_2\right)^2\left(30^2\right) = 30^4 29^2 = 2^4 \cdot 3^4 \cdot 5^4 \cdot 29^2$

Since, $400 = 2^4 \cdot 5^2$, $600 = 2^3 \cdot 3 \cdot 5^2$ and $8100 = 2^2 \cdot 3^4 \cdot 5^2$

We get N is divisible by each of 400, 600 and 8100.

Also N is divisible by four distinct primes. Viz. 2, 3, 5 and 29.

54. **(ABC)**

${}^mC_2 + 2 \cdot {}^mC_2 + {}^mC_1 \cdot {}^mC_2 \cdot 2 = N$

55. **(BCD)**

Since, α can be subtracted from β without borrowing, if $y_i \ge x_i$, for $i = 1, 2, 3$.

Let $x_i = \lambda$

If $i = 1$, then $\lambda = 1, 2, 3, \ldots.., 9$ and if i = 2 and 3, then

$\lambda = 0, 1, 2, 3, \ldots.., 9$

Hence, total number of ways of choosing the pair α, β

$$= \left(\sum_{\lambda=1}^{9}(10-\lambda)\right)\left(\sum_{\lambda=0}^{9}(10-\lambda)\right)^2$$

$$= (45)(55)^2$$

56. **(3720.00)**

57. **(31.00)**

$0! = 1!$

58. **(7200.00)**

Makes cases and use grouping and distribution.

59. **(135.00)**

${}^6C_2 \times D_4 = 15 \times 9 = 135$

60. **(651.00)**