Master Testing Agency
Practice papers, exam-standard · www.mastertestingagency.com

Optics — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · PHYSICS · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Use the Cartesian sign convention, with distances measured from the pole or optical centre, unless stated otherwise. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Master Testing Agency is an independent test-prep publisher, not affiliated with, endorsed by or connected to the National Testing Agency (NTA), the IITs or any other exam-conducting body.

Topics covered: Spherical mirrors and the mirror formula · Refraction at plane surfaces · Refraction at spherical surfaces · Thin lens formula and lens maker's formula · Total internal reflection and its applications · Magnification and power of a lens · Combination of thin lenses in contact · Refraction through a prism · Microscope and astronomical telescope · Wavefronts and Huygens' principle · Young's double-slit experiment · Coherent sources and sustained interference · Diffraction due to a single slit · Polarisation and Brewster's law

SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

1. An object is placed 10 cm in front of a concave mirror of focal length 15 cm. The image is

(1) virtual, erect, 3 times the size of the object and 30 cm behind the mirror

(2) real, inverted, 3 times the size of the object and 30 cm in front of the mirror

(3) virtual, erect, 1.5 times the size of the object and 6 cm behind the mirror

(4) real, inverted, 2 times the size of the object and 30 cm in front of the mirror

2. A point object in air is 30 cm from the convex spherical surface (radius of curvature 10 cm) of a long glass rod of refractive index 1.5, on its axis. The image is formed inside the glass at a distance from the surface of

(1) 30 cm

(2) 45 cm

(3) 90 cm

(4) 60 cm

3. A thin equiconvex lens made of glass of refractive index 1.5 has a power of +4 D in air. When it is placed in a transparent liquid of refractive index 1.6, it behaves as a

(1) converging lens of focal length 200 cm

(2) diverging lens of focal length 200 cm

(3) diverging lens of focal length 25 cm

(4) converging lens of focal length 12.5 cm

4. A thin plano-convex lens of refractive index 1.5 has a curved surface of radius 20 cm. Its plane surface is silvered. Light falling on the curved surface is brought to a focus as if by a concave mirror of focal length

(1) 40 cm

(2) 10 cm

(3) 80 cm

(4) 20 cm

5. An optical fibre has a core of refractive index 1.5 and a cladding of refractive index 1.4. The largest angle with the axis, measured in air, at which light entering the flat end of the fibre is still guided by total internal reflection is

(1) $\sin^{-1}(0.29)$

(2) $\sin^{-1}(0.93)$

(3) $\sin^{-1}(1.4/1.5)$

(4) $\sin^{-1}(0.54)$

6. A small bulb lies at the bottom of a tank of water (refractive index 4/3) 7 cm deep. Light leaves the water surface only through a circle of radius about

(1) 5.25 cm

(2) 7.9 cm

(3) 9.3 cm

(4) 10.5 cm

7. An object is placed 30 cm from a lens of power +5 D. The image is

(1) real, inverted, twice the size of the object and 60 cm from the lens

(2) virtual, erect, twice the size of the object and 60 cm from the lens

(3) real, inverted, half the size of the object and 12 cm from the lens

(4) virtual, erect, three times the size of the object and 60 cm from the lens

8. A convex lens of focal length 20 cm is placed in contact with a concave lens of focal length 30 cm. The combination acts as a

(1) converging lens of focal length 12 cm

(2) diverging lens of focal length 60 cm

(3) converging lens of focal length 60 cm

(4) converging lens of focal length 10 cm

9. The angle of minimum deviation of an equilateral prism made of glass of refractive index 1.5 is about

(1) 30.0°

(2) 48.6°

(3) 37.2°

(4) 45.0°

10. A thin prism of angle 6° and refractive index 1.5 is combined with a thin prism of refractive index 1.75, placed the other way round, so that light passing through both is not deviated. The angle of the second prism is

(1) 6°

(2) 3°

(3) 4.5°

(4) 4°

11. An astronomical telescope has an objective of focal length 100 cm and an eyepiece of focal length 5 cm. In normal adjustment (final image at infinity), its magnifying power and the distance between its lenses are

(1) 20 and 105 cm

(2) 20 and 95 cm

(3) 500 and 105 cm

(4) 0.05 and 105 cm

12. In a compound microscope the objective (focal length 2 cm) forms an image of an object placed 2.5 cm from it, and the eyepiece (focal length 5 cm) is set so that the final image is at the least distance of distinct vision, 25 cm. The magnifying power is

(1) 20

(2) 24

(3) 30

(4) 4

13. A large astronomical telescope is usually a reflecting telescope rather than a refracting one because

(1) for the same focal lengths it has a larger magnifying power

(2) a mirror objective has no chromatic aberration and a large mirror is easier to make and support than a large lens

(3) it gives an erect final image

(4) it does not need an eyepiece

14. According to Huygens' wave theory, when light of wavelength λ (in air) and frequency f enters glass of refractive index 1.5, inside the glass

(1) its wavelength is $\lambda/1.5$ and its frequency is still f

(2) its wavelength is still λ and its frequency is f/1.5

(3) its wavelength is 1.5λ and its frequency is still f

(4) both its wavelength and its frequency are reduced by a factor of 1.5

15. In Young's double-slit experiment with slits 0.5 mm apart, a screen 1 m away and light of wavelength 600 nm, the whole apparatus is immersed in water of refractive index 4/3. The fringe width becomes

(1) 1.2 mm

(2) 1.6 mm

(3) 0.6 mm

(4) 0.9 mm

16. In Young's double-slit experiment the intensities of the light from the two slits are in the ratio 1 : 4. The ratio of the maximum to the minimum intensity in the interference pattern is

(1) 4 : 1

(2) 16 : 1

(3) 9 : 1

(4) 25 : 9

17. In Young's double-slit experiment with light of wavelength 600 nm, one slit is covered by a thin glass sheet of refractive index 1.5. The central bright fringe moves to the position previously occupied by the fifth bright fringe. The thickness of the sheet is

(1) 3 μm

(2) 1.2 μm

(3) 12 μm

(4) 6 μm

18. Two separate sodium lamps placed side by side cannot produce a sustained interference pattern on a screen because

(1) their intensities are never exactly equal

(2) the phase difference between their waves changes randomly in a very short time

(3) they emit light of different wavelengths

(4) the light they emit is unpolarised

19. Light of wavelength 500 nm falls normally on a slit 0.1 mm wide. The width of the central bright band on a screen 1 m away is

(1) 10 mm

(2) 5 mm

(3) 20 mm

(4) 1 mm

20. Unpolarised light of intensity I_0 passes through three ideal polaroids. The first and the third are crossed, and the axis of the middle one is at 45° to both. The intensity of the light that emerges is

(1) zero

(2) $I_0/4$

(3) $I_0/8$

(4) $I_0/2$

SECTION B (Q21–25) · Numerical value · +4 / 0 / −1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

---

21. Unpolarised light falls on the surface of a glass of refractive index $\sqrt{3}$. The angle of incidence (in degrees) at which the reflected light is completely plane polarised is _____.

Answer: _____

22. The least possible distance (in cm) between an object and the real image formed of it by a convex lens of focal length 20 cm is _____.

Answer: _____

23. In Young's double-slit experiment the slits are 0.6 mm apart and the screen is 1.5 m away. The light contains two wavelengths, 600 nm and 480 nm. The distance (in mm) from the central fringe to the nearest point where bright fringes of the two wavelengths coincide is _____.

Answer: _____

24. An object on the axis of a concave mirror of focal length 20 cm is 30 cm from the mirror and moving towards it at 2 cm/s. The speed (in cm/s) of its image at that moment is _____.

Answer: _____

25. A glass slab 6 cm thick (refractive index 1.5) is placed between a point object and an observer looking at it along the normal to the slab. The object appears to be shifted towards the observer by (in mm) _____.

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(1)	(3)	(2)	(4)	(4)	(2)	(1)	(3)	(3)	(4)

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(1)	(2)	(2)	(1)	(4)	(3)	(4)	(2)	(1)	(3)

Q21	Q22	Q23	Q24	Q25
60	80	6	8	20

WORKED SOLUTIONS

Q1. Answer (1). With the sign convention u = −10 cm, f = −15 cm: 1/v = 1/f − 1/u = −1/15 + 1/10 = 1/30, so v = +30 cm (behind the mirror: virtual). m = −v/u = 3: erect and three times the size. The object is inside the focus, as in a shaving mirror.

Q2. Answer (3). $n_2/v - n_1/u = (n_2 - n_1)/R$ with u = −30 cm, R = +10 cm: 1.5/v + 1/30 = 0.5/10 = 1/20. So 1.5/v = 1/60 and v = 90 cm.

Q3. Answer (2). $1/f = (n/n_m - 1)(1/R_1 - 1/R_2)$. In air f = 25 cm with $n/n_m - 1 = 0.5$. In the liquid $n/n_m - 1 = 1.5/1.6 - 1 = -1/16$, which is −1/8 of 0.5. So f = −8 × 25 = −200 cm: the lens now diverges light, because the liquid is optically denser than the glass.

Q4. Answer (4). The lens alone has f = R/(n − 1) = 40 cm. Light passes through the lens, reflects at the plane mirror (power zero) and passes through the lens again, so the total power is $2/f_{lens} = 2/40$ per cm: an equivalent mirror of focal length 20 cm.

Q5. Answer (4). At the core–cladding boundary the ray must meet the wall at more than the critical angle: sin θ_c = 1.4/1.5. Inside, the ray's angle with the axis is then at most r with cos r = 1.4/1.5. At the end face sin i = 1.5 sin r = $\sqrt{(1.5^2 - 1.4^2)} = \sqrt{0.29} \approx 0.54$.

Q6. Answer (2). Rays meeting the surface beyond the critical angle (sin C = 3/4) are totally reflected. r = h tan C = 7 × (3/√7) = 3√7 ≈ 7.9 cm.

Q7. Answer (1). f = 1/P = 0.2 m = 20 cm. 1/v − 1/u = 1/f with u = −30: 1/v = 1/20 − 1/30 = 1/60, so v = +60 cm (real, on the other side). m = v/u = −2: inverted and twice the size.

Q8. Answer (3). Powers add: P = 1/0.20 − 1/0.30 = 5 − 3.33 = +1.67 D, so f = +60 cm, converging. (12 cm would be the result of adding both powers as positive.)

Q9. Answer (3). At minimum deviation the ray passes symmetrically, with r = A/2 = 30° inside: sin i = 1.5 sin 30° = 0.75, so i = 48.6°. δ = 2i − A = 97.2° − 60° = 37.2°. (48.6° is the angle of incidence, not the deviation.)

Q10. Answer (4). A thin prism deviates light by (n − 1)A. The first gives 0.5 × 6° = 3°. The second must give 3° the other way: 0.75 A′ = 3°, A′ = 4°.

Q11. Answer (1). In normal adjustment the image formed by the objective is at the focus of the eyepiece: separation $f_o + f_e$ = 105 cm. Magnifying power $m = f_o/f_e = 100/5 = 20$.

Q12. Answer (2). Objective: 1/v = 1/2 − 1/2.5 = 1/10, v = 10 cm, $m_o = -10/2.5 = -4$. Eyepiece with the image at 25 cm: $m_e = 1 + D/f_e = 1 + 25/5 = 6$. Magnifying power $|m_o\, m_e| = 24$.

Q13. Answer (2). Magnifying power still equals f_o/f_e, the image is still inverted and an eyepiece is still used. The advantages are optical and mechanical: a mirror reflects all colours alike (no chromatic aberration; a paraboloidal mirror also avoids

spherical aberration), and a mirror can be supported across its whole back, while a big lens sags and must be held by its rim.

Q14. Answer (1). In Huygens' construction the secondary wavelets travel at v = c/n in the glass, which gives Snell's law sin i/sin r = c/v = n. The frequency is fixed by the source (the wavefronts arrive at the boundary at the rate f), so λ = v/f becomes λ/1.5.

Q15. Answer (4). β = λD/d. In air β = 600 × 10⁻⁹ × 1/(0.5 × 10⁻³) = 1.2 mm. In water λ becomes λ/n, so β = 1.2/(4/3) = 0.9 mm.

Q16. Answer (3). Amplitudes are in the ratio √1 : √4 = 1 : 2. $I_{max} \propto (1 + 2)^2 = 9$ and $I_{min} \propto (2 - 1)^2 = 1$, so 9 : 1.

Q17. Answer (4). The sheet adds an optical path (n − 1)t to one beam. The central fringe moves to where the geometric path difference makes up for it: (n − 1)t = 5λ, t = 5 × 600 nm/0.5 = 6 μm.

Q18. Answer (2). Each lamp emits in short bursts from many atoms, with random phases. The phase difference between two independent sources therefore changes about every 10⁻⁸ s or faster, and the fringes shift too quickly to be seen. Sources must be coherent (constant phase difference), as when both beams come from one slit.

Q19. Answer (1). The first minima are where a sin θ = λ: θ ≈ λ/a = 5 × 10⁻³ rad. The central maximum stretches between the two first minima: width 2λD/a = 2 × 5 × 10⁻³ × 1 m = 10 mm.

Q20. Answer (3). The first polaroid passes $I_0/2$. By Malus's law the second passes $(I_0/2)\cos^2 45° = I_0/4$ and the third $(I_0/4)\cos^2 45° = I_0/8$. Without the middle polaroid no light would get through.

Q21. Answer 60. Brewster's law: tan θ_B = n = √3, so θ_B = 60°. (The reflected and refracted rays are then at right angles: the refraction angle is 30°.)

Q22. Answer 80. With u = −x and v = y (both positive distances), 1/x + 1/y = 1/f. The separation x + y is least when x = y = 2f, giving 4f = 80 cm.

Q23. Answer 6. Bright fringes of order n_1 and n_2 coincide when $n_1 \times 600 = n_2 \times 480$; the smallest solution is $n_1 = 4$, $n_2 = 5$ (path difference 2400 nm). y = 2400 × 10⁻⁹ × 1.5/(0.6 × 10⁻³) = 6 × 10⁻³ m = 6 mm.

Q24. Answer 8. 1/v + 1/u = 1/f gives dv/dt = −(v²/u²) du/dt. At u = −30 cm, v = −60 cm, so v²/u² = 4 and the image moves at 4 × 2 = 8 cm/s (away from the mirror).

Q25. Answer 20. Shift = t(1 − 1/n) = 6 × (1 − 1/1.5) = 2 cm = 20 mm, whatever the distance of the object from the slab.

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: mirrors, lenses, prisms and fibres by exact ray tracing with the laws of reflection and refraction, interference and diffraction by adding the waves at each point of the screen, and polarisation by Malus's law and the Fresnel equations.