D 143234 **(Pages : 2)** **Name.....**

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2026

(CBCSS)

Physics

PHY 4E 14—LASER SYSTEMS, OPTICAL FIBRES AND APPLICATIONS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*
Each answerable in 7.5 *minutes.*
Each question carries weightage 1.

1. Define einstein co-efficients.
2. Describe the principle of Fiber lasers.
3. What is non-linear refractive index ?
4. What is the role of lasers in isotope separation ?
5. What are optical fibers ?
6. What is the principle behind Q-switching in lasers ?
7. Describe the principle of the Z-scan technique ?
8. Define four-wave mixing.

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 5.

9. Derive the threshold condition for population inversion in a laser medium.
10. Explain the operation of Nd : YAG laser with its energy transitions.

Turn over

11. Discuss industrial applications of lasers with examples.

12. Differentiate between step-index and graded-index monomode fibers with diagrams.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

13. In a typical He-Ne laser the threshold population inversion density is $10^9 cm^{-3}$. What is the value of the population inversion density when the laser is oscillating in steady state with an output power of 2 mW ?

14. Consider mode locking an Nd : YAG laser and an Nd : glass laser. Compare the minimum pulse widths obtainable using these two lasers. If the length of the resonators in both cases is 20 cm, what typical pulse widths are possible by mode locking these two lasers ?

15. Consider absorption of photons by GaAs whose bandgap energy is 1.424 eV. The effective electron masses in the conduction band and the valence band are $0.067m_0$ and $0.46m_0$, respectively, where m_0 is the electron rest mass. If the incident photon wavelength is 850 nm, obtain the energy of the electron and hole generated by the absorption process.

16. An optical fiber has a core refractive index of 1.48 and cladding refractive index of 1.46.

    (i) Calculate its numerical aperture (NA).

    (ii) Determine the acceptance angle in air.

17. A hologram is recorded using a He-Ne laser (λ = 632.8 nm). The reference beam makes an angle of $\theta = 30°$ with the object beam at the recording plane. Find the fringe spacing of the recorded interference pattern.

18. A CO_2 laser (λ = 10.6 μm) delivers a power of P = 2 kW focused onto a spot of diameter d = 0.5 mm.

    (a) Calculate the intensity at the spot.

    (b) Comment on why this is suitable for cutting steel.

19. A Nd : YAG laser operating at λ = 1064 nm. is incident on a nonlinear crystal. Calculate the wavelength of the second harmonic generated.

(4 × 3 = 12 weightage)