

M.Sc. PHYSICS
FOURTH SEMESTER
LASER & NONLINEAR OPTICS
MSP-403 D
(USE OMR FOR OBJECTIVE PART)

**SET
A**

Duration: 3 hrs.

Full Marks: 70

(Objective)

Time: 30 min.

Marks: 20

Choose the correct answer from the following:

1X20=20

- For a pure state with density operator ' ρ ', which of the following condition is true?
 - $\text{Tr}(\rho)=1$
 - $\text{Tr}(\rho^2)=1$
 - both (a) and (b) are true
 - none of the above
- The completeness equation related to a two-state system having states $|a\rangle$ and $|b\rangle$ is
 - $|a\rangle\langle a| + |b\rangle\langle b| = 0$
 - $|a\rangle\langle b| + |b\rangle\langle a| = 1$
 - $|a\rangle\langle a| + |b\rangle\langle b| = 1$
 - $\langle a|a\rangle + \langle b|b\rangle = 1$
- The Rabi-oscillation associated with a two-level system and an external field E is given by
 - $\Omega_R = \frac{\hbar}{i} |\mu_{ab}| E$
 - $\Omega_R = \frac{\hbar |\mu_{ab}|}{E}$
 - $\Omega_R = \frac{|\mu_{ab}| E}{\hbar}$
 - $\Omega_R = \frac{\hbar E}{|\mu_{ab}|}$
- The dipole matrix approximation for a light-matter interaction suggests the following relation to be true
 - $K \cdot r = 0$
 - $K \cdot r = 1$
 - $K \cdot r \ll 1$
 - $K \cdot r \gg 1$
- Which among the following conditions indicates slow light?
 - $V_g > c$
 - $V_g < c$
 - $V_g = c$
 - $V_g \times c = 0$
- In Z scan technique the sign of the nonlinear phase shift $\Delta\phi > 0$ indicates____
 - Self-focusing
 - Self-defocusing
 - parametric generation
 - Self-modulation
- The Z scan technique measures which two among the following quantities?
 - Imaginary $\chi^{(1)}$, Real $\chi^{(1)}$
 - Imaginary $\chi^{(3)}$, Real $\chi^{(3)}$
 - Imaginary $\chi^{(2)}$, Real $\chi^{(2)}$
 - Imaginary $\chi^{(4)}$, Real $\chi^{(4)}$
- Select the true relation between n_2 and $\chi^{(3)}$, (n_0 being linear index of refraction)
 - $n_2 = \frac{3}{8n_0} \chi^{(3)}$
 - $n_2 = \frac{8}{3n_0} \chi^{(3)}$

c.
$$n_2 = \frac{\chi^{(3)}}{n_0}$$

d.
$$n_2 = n_0\chi^{(3)}$$

9. Which among the following is not determined by Z-scan technique
- Nonlinear absorption
 - Raman Effect
 - Nonlinear refractive index
 - Two photon absorption
10. In close aperture Z-Scan method, the phase shift for the case of $\Delta\phi > 0$,
- peak trails the valley
 - valley trails the peak
 - no peak and valley appear
 - none of the above.
11. The pump-probe method is successful in study _____ phenomena.
- ultraslow
 - ultrafast
 - stopped light
 - none of these
12. Sodium lamp used for Laser trapping are operated in _____ wavelength.
- 5890 nm
 - 5890 Å
 - 5890 μm
 - 5890 fm
13. The widely used laser in astronomy is
- argon laser
 - dye laser
 - Ruby laser
 - CO₂ laser
14. For liver and Lung treatment _____ and _____ lasers are widely used.
- Argon ion, He-Ne
 - dye, Ruby
 - Ruby, diod
 - Argon ion, CO₂
15. For cutting different types of materials, _____ lasers can be very useful.
- argon laser
 - dye laser
 - Ruby laser
 - CO₂ laser
16. A step index fiber supports single mode propagation if the V parameter is
- V=0
 - V<0
 - V<2.405
 - 2.405<V
17. Silica fiber made by MCVD method possesses a communication window.
- 340-750 nm
 - 1.0-1.3 μm
 - 1.5-1.6 μm
 - 4.0 μm -1.0 mm
18. For anomalous dispersion, the group velocity dispersion
- $\beta_2 < 0$
 - $\beta_2 > 0$
 - $\beta_2 = 0$
 - $\beta_2 = \infty$
19. At which wavelength the optical fibers possess minimum loss about 0.2 dB/km?
- 850 nm
 - 1.06 μm
 - 1.55 μm
 - 10.06 μm
20. Which among the following is described by the concept of numerical aperture in an optical fibre?
- Light collection
 - Light scattering
 - Light dispersion
 - Light polarisation

(Descriptive)

Time : 2 hrs. 30 mins.

Marks : 50

[Answer question no.1 & any four (4) from the rest]

1. If a single mode field \vec{E} interacts with a two-level atom, having states $|a\rangle$ (upper) and $|b\rangle$ (lower), with energy eigenvalues $\hbar\omega_a$ and $\hbar\omega_b$ associated with the states, respectively, then using completeness equation and dipole matrix element write the expressions for the following
Unperturbed Hamiltonian (H_0)
Interaction Hamiltonian (H_i) 4+6=10

2. a. What you mean by nonlinear optical susceptibility of a medium? Discuss the three-fold motivation towards obtaining nonlinear susceptibilities 5+5=10
b. What you mean by statistical mixture of states? Discuss the three step process, how density operator enable us to obtain all physical predictions be calculated from state vector $|\psi\rangle$

3. What you understand by electromagnetically induced transparency (EIT)? Discuss briefly about the three basic schemes of EIT. 4+6=10

4. Describe the operation of Z-scan technique. Discuss briefly the observations through Open and Close apertures 4+6=10

5. a. Discuss briefly the experimental technique of pump-probe spectroscopy. 5+5=10
b. Discuss why third-order nonlinear materials are important? Give examples of atomic vapour, dye solution and liquid that offer large nonlinearity

6. a. How can laser cooling be employed to trap neutral atoms? 5+5=10
b. Discuss two techniques how a laser can be used for communication.
7. Write briefly about the application of lasers in Plasma as well as for Thermonuclear fusion. 4+6=10
8. Describe the method of fabrication of optical fibers 10

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