National Open University of Nigeria
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Faculty of Sciences

Department of Pure and Applied Science

JANUARY 2018 Examination Questions

COURSE CODE: PHY406
COURSE TITLE: OPTICS III
CREDIT UNIT : 3
TIME: 3 HOURS
INSTRUCTION: Answer question 1 and any other four questions.

Take C = $3.0 \times 10^8 ms^{-1}$(velocity of light), h = 6.6×10^{-34}JS, $K_B = 1.38 \times 10^{-23}$ JK^{-1}(bohzmann constant).

Question 1

a) (i) What is meant by the term "coherence" of waves? ***2 marks***
(ii) If light of 660 nm wavelength has a wavetrain 20λ *long, what are its coherence length and coherence time?* ***5 marks***
(b)(i) What do you understand by the term areana ***2 marks***
(ii) If the visibility in an interference fringe pattern is 50 percent and the maxima receive 15 units of light, how much light do the minima receive? ***5 marks***
c) In optical fibre material briefly outline causes of power loss. ***5 marks***
d) How is the process of holography different from ordinary photography? 3 marks

Question 2

a) suppose we set up young's experiment with a small circular hole of diameter 0.1mm in front of a sodium lamp (λ = 589.3nm) source. If the distance from the source to the slit is 1m, how far apart will the slit be when the fringe pattern disappears? (4 marks))

b) A pulsed laser used for welding produces 100W of power during 10ms. Calculate the energy delivered to the weld (4 marks)

c) if the laser action occurs by the transition from an excited state to the ground state and it produces light of 693nm wavelength, what is the energy of the excited state? Take the ground state energy to be zero. (4 marks)

Question 3

a) Derive an expression for a system in thermal equilibrium according to Einstein. (4 marks)

b) Mention the three most commonly used ways of pumping a laser and achieving the population inversion necessary for stimulated emission to occur. (4 marks)

c) Briefly discuss the application of laser in:

i. medicine

ii. industry.

((4 marks)

Question 4

a. assume that an atom has two energy levels separated by an energy corresponding to a frequency 4.7 $\times 10^{14}$Hz. Let us assume that all the atoms are located in one or the other of these two states. Calculate the fraction of atoms in the upper state at room temperature T = 300k. (4 marks)

b) Why are liquid lasers more ideal as tunable lasers? (4 marks))

c. discuss some of the salient features of a hologram. (3 marks))

Question 5

a) Following Gabor, assume that amplitudes of signals and reference are in ratio 1:10, suppose that the two beams when they are combine may be completely out of phase or in phase. What is the maximum ratio of their intensities? (8 marks))

b. if the angle subtended at the hologram by the signal and the reference beam is 15^o. What wavelength is 492nm? (4 marks)

Question 6

a. what will happen if the refractive index of the cladding material is higher than that of the core? (2 marks)

b. if the core and cladding refractive indices for a step fibre is 1.47 and 1.46 respectively, what will be the broadening of a pulse after a distance of 5km? (3 marks)

c. . Suppose you have two optical fibres A and B. the refractive indices of the core (n_1) and the cladding (n_2) material is $(n_1)_A = 1.52$, $(n_2)_A = 1.41$, $(n_1)_B = 1.53$, $(n_2)_B = 1.39$. Which of the two fibres will have higher light gathering capacity? (4 marks)

d. A step – index fibre 6.35×10^{-5}m in diameter has a core of refractive index 1.53 and a cladding of refractive index 1.39. Determine the numerical aperture for the fibre and the acceptance angle (or maximum entrance cone angle). (3 marks)