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4313



MIDSUMMER EXAMINATIONS 2008 *Draft paper typeset with paexam v0.08 on January 25, 2008*

Subject PHYSICS, PHYSICS WITH ASTROPHYSICS
 PHYSICS WITH NANOSCIENCE AND TECHNOLOGY
 PHYSICS WITH PLANETARY SCIENCE
 PHYSICS WITH SPACE SCIENCE AND TECHNOLOGY

Title of paper COURSE 4313 – LASERS AND QUANTUM OPTICS

Time allowed Seventy-five Minutes

Instructions to candidates

Candidates should answer **TWO** questions.

The marking scheme for each question is indicated by the numbers in square brackets on the right-hand side of the question. Each question carries 20 marks.

NO PAPERS MAY BE REMOVED FROM THE EXAMINATION ROOM.

1. Explain the terms birefringence (also called double refraction) and optical activity. [6,6]
 What are retarders or wave plates? [2,8]
 Give three examples of types of wave plate indicating what they are used for. [6,14]
 Describe the construction and operation of a Pockels cell. [4,18]
 A Pockels cell has a retardance given by

$$\Delta\phi = 2\pi n_o^3 r_{63} V / \lambda_o$$
 where r_{63} is the electro-optic constant in m/V, n_o is the ordinary refractive index, V is the potential applied and λ_o is the free space wavelength in m. Calculate the half-wave voltage of the cell at $\lambda_o = 546.1$ nm if the cell material is KDP with $r_{63} = 10.6 \times 10^{-12}$ m/V and $n_o = 1.51$ at this wavelength. [2,20]
2. Describe the construction and principles of operation of an atomic gas laser. [8,8]
 Describe the construction and principles of operation of a semiconductor laser. [8,16]

P.T.O. . . .

What are the important quantitative differences between the light produced by an atomic gas laser and a semiconductor laser? [4,20]

3. Define the small signal gain for a collimated, monochromatic beam passing through the medium in a laser. [2,2]

Derive an expression for the small signal gain of a laser in terms of the number densities in the upper and lower levels of the laser transition, N_2 and N_1 , the frequency of the light, ν_{12} , the Einstein coefficient for the transition, B_{21} , and the refractive index of the material at the transition frequency, n . [8,10]

Hence show that a population inversion is required to provide a positive small signal gain. [1,11]

A laser cavity has length L and refractive index n . The mirror at one end is perfectly reflecting while that at the other end has a reflectivity R . Derive an expression for the life time of the cavity. [4,15]

If the mirror that produces the laser beam transmits 1% of the light, $n = 1$ and $L = 50$ cm estimate the resonant width of the cavity. [3,18]

The spectral width of the laser beam produced by such a cavity is always much narrower than this resonant width. Why is this? [2,20]