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**University Examinations 2015/2016**

FOURTH YEAR SECOND SEMESTER EXAMINATION

FOR THE DEGREE OF

BACHELOR OF SCIENCE

**SPH 2412: LASER AND MASER PHYSICS**

 **DATE: APRIL 2016 TIME: 2 HOURS**

**INSTRUCTIONS:** *Answer question* ***one*** *and any other* ***two*** *questions*

**CONSTANTS:**

1. Boltzmann constant, 
2. Speed of light,  in vacuum
3. Plank’s constants, 
4. 

**QUESTION ONE (30 MARKS)**

1. Distinguish between MASER and LASER (2 marks)
2. List four types of lasers using low density active medium whose wavelength fall in infrared. (2 marks)
3. With the aid of a diagram, explain the functions of the main components of a typical laser. (4 marks)
4. The spectral brightness of a 1mW laser beam could be very much greater than that of a 100W light bulb. Calculate the equivalent black body temperature a 1mW laser lamp can produce in the same number of photons in the spectral width  (3 marks)
5. Calculate the frequency, Energy and wave numbers of a photon of wavelength in vacuum (3 marks)
6. Distinguish between the two types of coherence of a laser beam (2 marks)
7. An interference filter with a bandwidth of 10nm centred at 500nm is used to obtain approximately monochromatic light from a white source.

Calculate the coherence time and the coherence length of the filtered light. (4 marks)

1. Name the processes that constitute laser action. (2 marks)
2. For the system in thermal equilibrium, calculate
3. The temperature at which the spontaneous and stimulated emission rates are equal for a wavelength of 500mm and
4. The wavelength at which these rates are equal at a temperature of 4000k.

(8 marks)

**QUESTION TWO (20 MARKS)**

1. Calculate the wave numbers corresponding to an energy spacing of kT where k is the Boltzmann constant and T is the absolute temperature

Assume . (3 marks)

1. For a cavity volume V= 1cm3calculate the number of modes that fall within a bandwidth centred at . (5 marks)
2. Consider the thermal radiation field at room temperature (300k). Determine
3. The number of modes per m3 and
4. The average number of photons in the bisible range () for the spectral interval of  (7 marks)
5. For a Nd: YAG Laser crystal located in a cavity of length 0.1m, determine:
6. The frequency separation among the axial modes.
7. The number of axial modes. (5 marks)

Assume that the laser is operating in a laser line at 1.06 whose full width dv is 1.1 x 1011Hz.

**QUESTION THREE (20 MARKS)**

1. Distinguish between homogeneous and inhomogeneous broadening stating the resultant line shape function for each case. (3 marks)
2. An allowed emission transition for an optical ion in a solid has a lifetime of 10ns. Estimate its natural broadening, then estimate the peak value g(v). (6 mark)
3. Calculate the Doppler broadened line width for the 488 nm transition of an argon ion laser given that the temperature of the discharge is 6000k and the atomic mass unit of argon is 39.95. (3 marks)
4. A homogeneously broadened transition of a 5cm long gain medium has an unsaturated gain coefficient at line center of  and a saturation intensity of  A monochromatic E-M wave resonant with the gain transition, with an intensity of  enters the gain medium. Calculate the output intensity. (8 marks)

**QUESTION FOUR (20 MARKS)**

1. Suppose that a 7.5cm length rod of a Nd: YAG laser crystal is located in a linear cavity with two mirrors of transmittances and  at the laser wavelength 1.06µm. If the cross-section is  determine the population inversion density at threshold. Assume that losses are only due to the output mirror transmittance. (5 marks)
2. The rate of spontaneous emission  of a homogeneously broadened laser transition at  is while its line width. The degeneracies of the lower and upper level are and  respectively.
3. Calculate the stimulated emission cross-section at line center. (4 marks)
4. Calculate the population inversion to obtain a gain coefficient of 5m-1 (3 marks)
5. Calculate the gain saturation intensity assuming that the life time of the upper state is 10$μ$s and that of the lower state is 0.1$μ$s. (3 marks)
6. With the aid of well labeled diagrams, distinguish between three – level and four – level laser systems. Explain why three – level lasers are not as efficient as four – level lasers. (5 marks)