KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

FIRST SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELLOR OF SCIENCE AND BACHELOR OF EDUCATION (SCIENCE)

SPH 424: MASERS AND LASERS

DATE: Monday 5th December 2011 **TIME: 2.00p.m – 4.00p.m**

INSTRUCTIONS:

1. Answer question No. **1** and any other TWO questions.
   Question No. 1. Carries 30 marks, while the others carry 20 marks each.

2. Use of sketch diagrams where necessary and brief illustrations are encouraged.
   Read the instructions on the answer booklet keenly and adhere to them

QUESTION 1.

A i. Explain in brief how the feedback element in a general Laser device functions. [2]

ii. How can a feedback step be achieved in a Maser device? [4]

B. A laser beam with a source power of 500 mW, a wavelength of 9.0×10^{-7} m and an aperture of $4.5 \times 10^{-4}\ m$ is focused on a object located in space. If the angular spread is 2.0×10^{-3} radians then, Calculate the following parameters;

i. Object's range from the source. [2]

ii. area spread of the beam when it reaches the object. [2]

C. Explain in details the use of lasers in one area of your choice. [6]

D. A laser beam of irradiance 250 W/m², is directed into an optical resonator of length 1m, gain coefficient 0.85 and having an intensity loss per unit meter of 0.45. On emerging from the cavity,

i. What will be the beam's solid angle in radians, given that the beam's cross section is circular? [2]

ii. Calculate the irradiance from the source. [4]

iii. Find the reflectivity of the arrangement and hence [4]

vi. Calculate the net round trip power gain of the laser. [4]

QUESTION 2.

A. Explain the function of a resonator in general , in Laser technology? include a well labelled diagram. [5]

B i. Draw a well labelled representation of an atomic transition line shape. [4]

ii. Calculate the intensity of a transition spectral line at 50 Hz., if the transition obeys a Lorentzian function.
Given that frequency of the line peak (ω_o) is 30 Hz and the full width at half maximum ($\Delta\omega$) is 3.5 Hz. [4]

C i. What are spectral lines? [1]
How can they be obtained experimentally for a chemical agent (such as potassium)? [3]

ii. Explain where and how chemical spectral line analysis is exploited in real life situations. [2]

QUESTION 3.

A . What do you understand by the term maser principle? [4]

B. With the help of diagrams, show and explain the various steps involved in a three-level pumping scheme in a laser device and list all it's characteristics. [6]

C. A laser beam has a divergence of 0.25 milliradians.

i. If the beam's cross section is circular, calculate the magnitude of the solid angle formed by the beam. [2]

ii. If the power of the beam is 25 mW, calculate the irradiance at a point 10 m from the source. [2]

D. Distinguish between gaslasers and liquid lasers. [6]

QUESTION 4.

A i. Differentiate between stimulated emission and spontaneous
ii. emission of radiation. [4]

B. Derive the Boltzmann equation for the distribution of atoms in the various energy levels. [8]

C Explain the following terms with regard to a laser device;
i. Source aperture,
ii. Angular spread,
iii. Area spread,
iv. Active medium. [8]

QUESTION 5.

A. Elaborate fully on the causes of lineshape broadening in laser transitions? [8]

B. i. Define Einstein's A and B coefficients in laser study? [4]
ii. What are their significances?
iii. Derive Einstein's A and B coefficients by the help of a two-scheme atomic system. [8]