MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPH 212: APPLIED OPTICS AND TECHNOLOGY

DATE: 29/8/2022 **TIME: 11.00-1.00 PM**

INSTRUCTIONS:

Answer **QUESTION ONE** and **ANY OTHER TWO** questions.

Question 1 carries **30** marks and the others carry **20** marks each.

YOU MAY USE:

You may need to use the following constants:
Plank's constant= 6.63×10^{-34} m^2kg/s, Boltzmann's constant, K = 1.38×10^{-23} m^2 kg s^{-2} K^{-1}, c=2.998×10^8 m/s, Stefan–Boltzmann constant= 5.67 x 10^{-8} W m^{-2} K^{-4}, $\varepsilon_o = 8.85 \times 10^{-12}\ Nm^2C^2$, $\mu_o = 4\pi \times 10^{-7}$ TmA,

QUESTION ONE (COMPULSORY) (30 MARKS)

a) You are designing a laser cavity that will produce a maximum gain. Identify the factors considered to ensure that the amplifying medium gives the highest gain. (4 marks)

b) If the refractive indices of the fibre core and cladding are 1.46 and 1.35 respectively, under what conditions will the light be trapped within the core? (2 marks)

c) Calculate the ratio of the stimulated emission rate to the spontaneous emission rate for an incandescent lamp operating at a temperature of 1000 K. Assume that the average operating wavelength is 0.5 mm. (4 marks)

d) State Kirchoff's law of radiation (2 marks)

e) If the typical loss in a single-mode fibre is 0.2 dB/km, calculate the maximum distance that a 15 dBm optical signal can be transmitted if a -18 dBm receiver is to be used. (2 marks)

f) State Stefan-Boltzmann law of radiation. (2 marks)

g) Discuss any two applications of polarimeters in modern day technology (4 marks)

h) List any three pumping mechanisms of a laser (3 marks)

i) Describe the three dispersion mechanisms (3 marks)

j) Describe the inverse square law of radiation and its relevance to optics (4 marks)

QUESTION TWO

a) Discuss the energy distribution based on the Classical and Quantum models (4 marks)

b) Using a suitable diagram, describe the operational principle of Hall-effect for measuring magnetic field density (6 marks)

c) Describe the following processes in relation to laser;

(i) Absorption (2 marks)

(ii) Spontaneous emission (2 marks)

(iii) Stimulated emission (2 marks)

d) Describe the four properties of lasers (4 marks)

QUESTION THREE

a) The wavelength of maximum solar emission is observed to be approximately 0.475 μm. Calculate the surface temperature of the sun (assumed as blackbody). (4 marks)

b) State Beer-Lambert's law and plot its profile (4 marks)

c) Discuss the main components of an optical fibre (6 marks)

d) Describe the 3-level and 4-level processes for the Ruby and He-Ne lasers respectively. (6 marks)

QUESTION FOUR (20 MARKS)

a) Describe the basic principle of operation of a polarimeter. (6 marks)

b) A spherical black body of radius 12 cm radiates 450 W power at 400 K. If the radius was halved and the temperature doubled, calculate the radiated power. (4 marks)

c) Using relevant and supporting theories, describe the quantum nature of light. (4 marks)

d) With the help of a neat block diagram, design a simple point to point optical fibre-link. (6 marks)

QUESTION FIVE (20 MARKS)

a) Identify the advantages of using optical fibre transmissions over copper cable. (5 marks)

b) List the link properties that can be detected or measured by an optical time domain reflectometer. (5 marks)

c) Show that the numerical aperture of an optical fibre is given by;

$NA = \sqrt{(\eta_1{}^2 - \eta_2{}^2)}$ where η_1 and η_2 are the refractive indices of the core and cladding respectively (5 marks)

d) Define multiplexing and identify any four multiplexing techniques for improving the capacity of a single mode fibre (5marks)